**BEAMREACH NETWORKS, INC.**
**BELLSOUTH CORPORATION**
**VERIZON WIRELESS, INC.**
**WORLDCOM, INC.**

November 2, 2001

**Ex Parte**

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

*Re: Establishment of Rules and Policies for the Satellite Digital Audio Radio Service in the 2310-2360 MHz Band; IB Docket No. 95-91*

Dear Ms. Salas:

This letter addresses recent filings of XM Radio, Inc. ("XM") and Sirius Satellite Radio. Inc. ("Sirius) in the above-referenced matter. The attached White Paper responds to XM's 10/24/01 *ex parte* filing and extends previous work done by Wireless Communications Service Parties (WCS Parties) analyzing SDARS licensees' technical plans for deployment of terrestrial repeater networks. [1] The WCS Parties' 10/7/01 filing contained preliminary findings that were based on information previously made available by XM and Sirius. That information, however, since has been supplemented by additional filings by XM and Sirius, and by several technical conversations, some of which were initiated by FCC staff. The further analysis in the attached White Paper provides examples and calculations involving specific cities, signal levels, station locations, and antenna patterns that are representative of the types of interference that will occur where SDARS transmitters operate. It is important to note, however, that while this analysis is based on information made available more recently by XM and Sirius, it does not include analysis of potential interference from transmitters operating at less than 2 kW, because neither SDARS licensee has provided that information to any WCS or MDS licensee.[2]

The findings, in summary, are as follows:

- Additional filtering at the WCS base station will not resolve interference problems with high-power SDARS repeaters. While adding filters is technically feasible, the cost of such filters is

[1] Letter from BellSouth Corporation, WorldCom Broadband Solutions, Inc., Verizon Wireless, Metricom, Inc., Wireless Communications Association International, Inc., and BeamReach Networks, Inc., to Magalie Roman Salas, IB Docket No. 95-91, File No. SAT-STA-20010712-00063 and File No. SAT-STA-20010724-00064 (dated Sept. 7, 2001).
[2] In a letter dated September 25, 2001, Carl Frank, counsel to Sirius, responded to BellSouth's September 20, 2001 request for information, stating that "Sirius is investigating the deployment of several repeaters less than 2 kW prior to December 31, 2001."

significant and it may not be economically feasible to employ them in all WCS installations. Moreover, base station interference is only half of the problem. It is not feasible to employ such filters in WCS customer premises equipment (CPE) due to the size and cost of such filters. It is important to remember in this regard that WCS licensees are deploying two-way systems whereas SDARS licensees are deploying one-way systems.

- The use of automatic gain control ("AGC"), including in the RF front-end, will not solve the interference problems caused by high-power SDARS repeaters. Even where RF AGC can be used to reduce interference, it does so by shrinking WCS cell size and consequently increasing cost of coverage for the WCS operator. Thus, XM's AGC proposal does not "fix" the problem at all, but merely shifts the economic burden from the source of the interference to the recipient of the interference.

- XM's analysis is based on a definition of effective isotropic radiated power ("EIRP") that conflicts with standard practice. The FCC should maintain its long-established and widely-accepted working definition of EIRP. SDARS licensees should understand that belated attempts to redefine EIRP through the use of antenna patterns is unwelcome and self-serving, introducing unwanted and unnecessary confusion to these proceedings.

XM's White Paper contains little new information and, with the exception of the link budget discussion, repeats information contained in its 8/29/01 filing. Whenever additional details have been provided, however, they have been incorporated into this analysis.

Sirius contends that the Commission does not need to seek additional comments in this proceeding and that further delay would be contrary to the public interest. It also claims that rules proposed by AT&T Wireless ("AWS") are overly complicated and would unduly burden Sirius.[3] None of these contentions has merit.

Despite the fact that the Commission has made it clear since 1995 that it needs additional information from XM and Sirius in order to develop service rules, XM and Sirius only recently provided some detailed information on the location and operation of their terrestrial repeater networks. In order to satisfy its duty to develop rules and set policies that will serve the public interest, the Commission now must seek additional comments on this new information.

As reflected in the attached White Paper and other submissions, the WCS Parties have established through sound engineering analyses that operation of SDARS high power terrestrial repeaters will cause debilitating brute force overload and intermodulation distortion to the detriment of WCS licensees and customers. Neither Sirius nor XM has been able to refute these showings. Moreover, neither XM nor Sirius has offered any valid reason why the Commission should allow them to operate in light of the harmful interference they will cause. At the same time the SDARS licensees

[3] Letter from Carl R. Frank to Magalie Roman Salas, IB Docket No. 95-51 (dated Oct. 25, 2001).

equate their private interests with the public interest, they also seek to elevate their interests above those of other licensees and their customers.

The public interest requires the Commission either to deny Sirius' request to operate high power terrestrial repeaters or to design rules that ensure that SDARS operations will not interfere with WCS operations. The rules proposed by Sirius do not provide such protection and therefore must be rejected. AWS recently submitted a more balanced proposal that provides such protection and contemplates a generous SDARS transition period, and further comment on the AWS proposal could help the Commission develop balanced rules, in the public interest.

In expressing concern about delay and the number of submissions in this proceeding, Sirius overlooks its own failures to provide information to the Commission in a timely fashion and its legal duty to avoid creating harmful interference to other licensees. Moreover, contrary to Sirius' assertion, the Commission will gain new information from another round of comments, as evidenced by the attached White Paper in which the WCS parties again produce analyses refuting arguments put forth by XM and Sirius.

While the proposed AWS rules are detailed, those details create a fair transition period that will permit SDARS licensees to operate high power terrestrial repeaters for several years and to re-engineer their networks. However, if Sirius is troubled by such detail, the Commission can easily eliminate that concern by adopting rules that require Sirius to immediately cease operating terrestrial repeaters at levels above 2 kW.

It would not be unfair for the Commission to require Sirius to re-engineer its terrestrial repeater network to a 2 kW standard. Sirius built its network in the absence of rules and at its own risk. Moreover, the WCS Parties have shown that (i) re-engineering the SDARS terrestrial network is necessary for SDARS licensees to meet their obligation not to create harmful interference to WCS licensees; (ii) they have engineered state-of-the-art networks and CPE, and do nothing to exacerbate Sirius' problems; and, (iii) there is no principle in law or policy that requires WCS licensees, who cause no harmful interference, to share in the cost of re-engineering SDARS networks.

Sincerely,

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cc: Hon. Michael K. Powell
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# Response to XM Radio's Supplement to August 29,2001 White Paper[1]

Over the past several months the WCS Parties and the SDARS licensees have engaged in an ongoing dialogue with each other and with the FCC regarding SDARS terrestrial repeater interference.[2, 3,4] The primary issue being discussed has been the level of interference which will be experienced by WCS licensees should the FCC grant SDARS licensees the right to operate high power terrestrial repeaters in the SDARS band, between and immediately adjacent to WCS channel blocks C & D. This dialogue has resulted in a number of filings before the commission, as well as several less formal meetings and technical discussions in an attempt to resolve the interference issue(s) at hand.

The purposes of this Ex Parte are as follows:

1. To provide a specific, detailed and clear response to the XM Ex Parte supplementing its August 29, 2001 white paper, "Potential Blanketing Interference from DARS Repeaters to WCS Receivers", which was submitted to the FCC on September 24, 2001.[5]

2. To insure that *the commission's technical staff has been* given, in writing the *specific reasons* why granting the licenses proposed by the SDARS operators will cause harmful interference and economic damage to WCS licensees. *These reasons are cited herein and are proved through technical analysis,* using RF modeling techniques well established and accepted within the industry.

XM's basic proposals are nearly identical to its proposals in its filing of August 29, 2001. They contain no new information of significance, although some of the information in its previous filings has been expanded and further explained. Thus, the WCS Parties have come to the same conclusion as has been expressed before in previous filings and meetings with the FCC: *The interference solutions proposed by XM will not provide an adequate solution to the harmful interference caused by their high-powered SDARS repeaters.*

In the remainder of this paper, the WCS operators show that XM's proposals do not provide an adequate solution to the interference created by XM's (and Sirius') high-powered terrestrial repeaters.

In summary:

1. <u>Additional filtering at the WCS base station will not resolve the interference problems.</u> Cavity filters employed in WCS base stations can reduce blanketing interference and intermodulation distortion from high-powered SDARS repeaters. However, the cost of such filters is significant, and it may not be economically feasible to employ them in all WCS installations. Moreover, base station interference is only half of the problem.

   WCS operators are installing two-way systems, and particularly from a financial perspective, the primary problem of interference to customer premise equipment ("CPE") remains more difficult

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[1] This response was prepared by BellSouth Corporation, WorldCom Broadband Solutions, BeamReach Networks, and Verizon Wireless ("WCS Parties").

[2] See, Letter from Bruce Jacobs and Konczal, Counsel for XM and Sirius, to Magalie Roman Salas, IB Docket 95-91 (September 5, 2001).

[3] See, Letter from Bruce Jacob, Counsel for XM Radio, to Magalie Roman Salas, IB Docket 95-91 (September 7, 2001).

[4] See, Letter from Paul Sinderbrand, Counsel for WCA, to Magalie Roman Salas, IB Docket 95-91 (October 3, 2001).

[5] *See*, Letter from Lon C. Levin, Counsel to XM Radio, to Magalie Roman Salas, IB Docket No. 95-91 (September 24, 2001).

both from a size and a cost perspective. Thus, even if base station interference is completely eliminated, the WCS operators' problem remains unsolved.

2. The use of automatic gain control ("AGC") will not solve the interference problems. While receiver AGC may work for the SDARS operators' interference problems, it does not solve the problems faced by WCS operators. AGC (including in the RF front-end) is already employed in WCS receivers.

   The problem is that the SDARS blanketing interference causes the RF AGC proposed by XM to reduce the dynamic range of the CPE receiver. By attenuating the input signal to the CPE to block the SDARS interference, the intended WCS signal is also strongly attenuated. This effect, in turn, reduces the effective coverage of the WCS operator's cell and increases the cost of coverage for the WCS operator. Consequently, the XM proposal does not "fix" the interference problem, because it imposes an unacceptable economic burden on the WCS operators.

3. Replacing high-power repeaters with a larger number of low-power repeaters will not increase the total area of the exclusion zone.

   XM's own filing of August 29, 2001 refutes this claim in two of the three cases presented by showing that the effective reduction is relatively small (about 10%). Absent the details of how its calculations were made, it is impossible to comment on the third case that it presented which shows a 48% reduction.

   Further, XM's filing shows that the real reason it wants high-powered repeaters is that it solves self- interference problems commonly known to be a problem in simulcast systems. XM simply attempts to fixes its own problems by imposing expenses on WCS operators.

## RF System Design

On page two of the XM's supplement, XM comments on two-way system design. The WCS Parties respond as follows:

XM Radio's proposal for a solution to the WCS CPE interference problems caused by SDARS repeaters is a clear indication that XM knows that the problem exists and has tried to ignore it. However, the WCS licensees have shown that XM's "solution to the CPE problem" will not mitigate the interference problems at the WCS CPE or provide an economically acceptable solution to the WCS CPE problem.

## Base Station Filters

On page three of the XM's supplement, XM comments on base station filters. The WCS Parties respond as follows:

> Cavity filters for WCS base stations can reduce blanketing and intermodulation interference caused by high-powered SDARS repeaters to acceptable levels. The WCS Parties have stated this before in many discussions with SDARS licensees and in filings to the FCC.
>
> However the cost to the WCS operators can range from $1250 for a custom design to about $300 for an off-the-shelf design. Depending on the number of antennas at each WCS site, the impact on overall system deployment costs can be substantial.
>
> This cost penalty for base station filters should not be borne by the WCS licensees. Rather the costs should be borne by the "cost causer", namely the operator(s) causing the interference – the SDARS licensees.

## Front-End RF AGC for WCS CPE

On page four of the XM's supplement, XM comments on front-end RF AGC for WCS consumer equipment. WCS Parties respond as follows:

> In XM's supplement as well as its white paper, XM recommends to the WCS licensees the use of front-end AGC in their CPE equipment to "protect against intermodulation and front-end overload". XM's proposed "interference fix" is really no fix.
>
> First, the front-end AGC is already incorporated in most well-designed WCS receivers. It detects the offending interference and either inserts loss in the front-end of the receiver reducing the input signal or reduces the gain of the first Low Noise Amplifier (LNA), which in essence reduces the input signal.
>
> XM's attempt to show that AGC works in a single cell WCS deployment fails completely because it is based on various erroneous assumptions. XM also mentions that the RF front-end AGC fix works in the paging industry and in cellular CDMA systems that must operate in the presence of cellular AMPS base stations. XM has even attached information from a Qualcomm patent addressing the above AGC fix.
>
> XM fails to mention that the Qualcomm patent covers systems deployed with similar power (EIRP) levels. This is not the case with SDARS repeaters and WCS base stations with power differences as high as 55 dB (over 300,000 times higher).
>
> In our earlier responses[6], we have shown that the WCS licensees understand the RF front-end AGC proposed solution. However, XM's "proof" that the front-end AGC proposed fix completely protects all CPE within a WCS service area is flawed and leads to the wrong conclusion.
>
> The success of a front-end AGC fix is predicated on the premise that the power gap between the interfering signal and the desired signal levels at the receiver's front-end is within a certain range. This range is dependent on the minimum receive level of the WCS receiver and either the overload threshold or the intermodulation threshold of the WCS receiver.
>
> If the difference between the interfering signal level and the desired signal level at the receiver front-end is within the power gap, AGC works for that type of interference. If it is greater than the power gap, AGC does not work. Shown in Figure 1 is a graphic representation of the power gap requirement.
>
> As is obvious from Figure 1, the power levels of the interfering and desired transmitters must be similar if the two transmitters are in the same area. If they are not in the same area, they must be at different power levels and at an appropriate distance from each other as to afford enough path loss to bring the received levels within the power gap range.

XM's Erroneous Assumptions:

In its Supplement, XM made a number of erroneous assumptions concerning WCS system characteristics and deployment strategies in its attempt to prove its case for front-end AGC. The erroneous assumptions used in the XM supplement are as follows:

- The WCS licensees use an average base station transmit power of 2 kW;

[6] Id. in "Response to White Paper", at 3.

- The WCS deployment strategy employs single cell deployments;
- The minimum receive level for WCS receivers is a –101 dBm; and
- WCS licensees operate their systems with excess link margins (excess meaning above that required for the system to perform at the rated bit error rate, probability of cover, and availability).

The correct assumptions are as follows:

- The average base station power levels (EIRP) used in BellSouth/WorldCom studies range from 2 watts to 125 watts.
    - The WCS licensees use a more cellular approach to wireless network design, unlike the broadcast approach of the SDARS licensees. In cellular networks the forward and reverse links are balanced, therefore base station power is kept low to keep the CPE power low.
    - Base station power in cellular networks is also kept low because cell sizes are small compared to a broadcast network's cell.
    - Cell sizes are small because spectrum is limited, and with a multi-cell deployment, more than one channel is required in each cell for capacity.
    - Base station transmit power is also kept low to minimize the impacts of intercell interference on the network's ability to reuse channels.
- As stated above WCS licensees deploy a multi-cell network not a single cell network for capacity reasons and to be more efficient with their assigned spectrum.
- The minimum receive level for BellSouth/WorldCom receivers is the receiver noise threshold plus the Carrier-to-Noise ratio required for the modulation type used and the bit-error-rate required, which for BellSouth is – 80 dBm.
    - The minimum receive level for WCS licensees' receivers is a function of the equipment used during deployment. In their Supplement, XM used a –101 dBm as the minimum receive level for WCS receivers. This number was obtained from a BellSouth filing.[7]
    - In actuality, the –101 dBm number obtained from the BellSouth filing was for the receiver noise threshold or noise floor not, as interpreted by XM, the minimum receive level.
- Most WCS system designs are predicated on the fact that at the cell boundary the receive level is such that within a certain confidence level the bit error rate, probability of coverage, and availability requirements will be met. This means that at the boundary of the cell, there is no excess link margin. This also means that as a CPE unit gets closer to the base station, the excess link margin increases.

There are many ways to demonstrate through the use of widely accepted modeling techniques the impact SDARS repeaters will have on WCS systems. Studies of this nature must focus on the following:

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[7]See, Comments Of BellSouth to XM and Sirius' Request for STA (filed August 21, 2001), in Attachment A.

1. The impact on a single WCS cell from a SDARS repeater collocated with the WCS cell's base station. In this case all WCS CPE is pointed at the SDARS repeater with no CPE antenna discrimination taken into consideration. This is the type of study done in BellSouth's Comments to XM's and Sirius' request for STA.

2. The impact on a single WCS cell from a SDARS repeater separated in distance from a WCS base station with the CPE antennas pointed at the WCS base station and the antenna discrimination of the CPE to the SDARS interfering signal taken into consideration.

3. The impact of front-end AGC in the WCS CPE on a single WCS cell from a SDARS repeater separated in distance from, or collocated with a WCS base station.

4. The impact of different SDARS transmit power levels on a single WCS cell.

As examples of how the power gap applies to individual operator's systems, studies of front-end AGC performance using both theoretical and real-world parameters are presented.

## BellSouth Studies

The first BellSouth study described below investigates the impacts of interference situations one, three and four above. It shows the impacts of CPE AGC and variations in SDARS power levels to a single WCS cell. The second study investigates all four interference impacts.

BellSouth Study I: The first study is one similar to that done by XM in its Supplement. The study makes calculations at various points within WCS cells along a radial emanating from the SDARS repeater site to determine if a SDARS interfering signal is above the interference thresholds and if front-end AGC can mitigate the problem. The WCS CPE is always pointed towards the SDARS repeater and no points are selected where antenna discrimination applies. A layout of the SDARS system and the BellSouth WCS cells along the radial is shown in Figure 2. Calculations were made with the following study parameters:

1. The WCS base station transmit power (EIRP) was 15 watts.

2. The propagation constant for the SDARS interfering signal path was 2 (line-of-sight).

3. The propagation constant for the WCS signal path to the CPE was 3.

4. WCS deployment uses a multi-cell deployment with each cell having a radius of 5 miles.

5. WCS CPE antenna is directional with a gain of 17 dBi.

6. The Fade Margin was 10 dB.

7. Minimum WCS receive signal level was –80 dBm (16QAM with a BER of $10^{-7}$).

8. The overload threshold level was –35 dBm at the receiver input.

9. The Intermodulation threshold was –60 dBm at the receiver input.

10. The power gap for overload interference is 45 dB.

11. The power gap for intermodulation interference is 20 dB.

The results of the calculations are shown in Table 1.

Table 1 shows that XM's AGC proposed solution does not work to reduce overload and intermodulation interference to acceptable levels in all areas of a WCS deployment even when the SDARS transmit power level is 2 kW.

In addition, the following can be shown:

1. As SDARS power levels are increased, the WCS CPE receiver must be moved farther away from the SDARS site in order to allow the AGC to work.

2. SDARS power levels must be reduced to 2 kW before the AGC can mitigate the effects of overload interference without affecting WCS performance at the edge of the first WCS cell.

3. Intermodulation interference is the controlling form of the two types of interference studied. For a 40 kW SDARS transmit power level, one must go out from the SDARS site 29 WCS cells (285 miles) before the intermodulation interference is below acceptable limits at the cell boundary. For a 2 kW SDARS transmit power level, the number of cell is seven (65 miles).

BellSouth Study II: The second study done by BellSouth uses computer modeling to determine the areas within a WCS deployment where AGC does not mitigate the affects of SDARS interference. The computer modeling tool used was EDX.

Three WCS sites were studied. One WCS base station was located near the SDARS repeater site with the designation ATL16WCS. A second WCS base station was located two miles from the SDARS repeater site with the designation ATL04BST, and the third WCS base station was located 8 miles from the SDARS repeater site with the designation ATL08WCS.

The EDX program calculated the difference between the WCS receive level and the SDARS receive level at all points in the study area. If the difference in power levels was more negative than –20 dB, the AGC solution did not mitigate the interference affects in that area for the two types of interference under study.

In the areas where the difference was –20 dB or higher (less negative), the AGC solution was successful in mitigating the interference problems of both types of interference. Otherwise, the AGC solution was unsuccessful.

The following parameters were used in the study:

1. The WCS base station transmit power (EIRP) was 2 watts.

2. WCS CPE antenna is directional with a gain of 17 dBi.

3. WCS CPE antenna height was 25 feet above ground level.

4. Minimum WCS receive signal level was –80 dBm (16QAM with a BER of $10^{-7}$).

5. The overload threshold level was –35 dBm at the receiver input.

6. The intermodulation threshold was –60 dBm at the receiver input.

7. The power gap for overload interference was 45 dB.

8. The power gap for intermodulation interference was 20 dB.

9. The Atlanta, Georgia market was used as the study area.

The results of the EDX modeling are shown in Figures 3 through 18. The results of the EDX modeling are also discussed below.

**Demonstration of Cell Coverage Without SDARS Interference**

Figure 3 shows the RF coverage area of WCS base station ATL04BST that is located 2 miles from a non-transmitting SDARS site collocated with WCS base station ATL16WCS. The usable RF coverage includes the areas shown by the colors green and yellow. RF coverage varies from 3 to 6 miles.

**Problem Demonstration 1: Non-collocated 40 kW SDARS Interference Into WCS Cell 2 Miles Away (Theoretical)**

**Result: 41 % Reduction in Coverage Area of WCS CPE**

In Figure 4 the SDARS transmitter collocated with WCS base station ATL16WCS is turned on with an EIRP of 40 kW. This simulation again looks at the RF coverage area of WCS base station ATL04BST. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The new WCS cell coverage is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less.

- The areas colored by yellow and red are the areas where AGC does not work for intermodulation interference.
- The area colored in red is the area where AGC does not work for overload interference.

Because of the inability of the AGC to mitigate the interference, the WCS cell radius has been reduced to 0 to 4 miles with ***a loss in area covered of 41%***.

**Problem Demonstration 2: Non-collocated 7.3 kW SDARS Interference Into WCS Cell 2 Miles Away (Actual)**

**Result: 22 % Reduction in Coverage Area of WCS CPE**

In Figure 5 the SDARS transmitter collocated with WCS base station ATL16WCS is turned on with an EIRP of 7.3 kW. This SDARS EIRP is the level stated in the XM STA application. This simulation again looks at the RF coverage area of WCS base station ATL04BST.

The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The WCS cell coverage at this SDARS EIRP is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less.

- The areas colored by yellow and red are the areas where AGC does not work for intermodulation interference.
- The area colored in red is the area where AGC does not work for overload interference.

Because of the inability of the AGC to mitigate the interference, the WCS cell radius has been reduced to 0.5 to 5 miles with ***a loss in area covered of 22%***.

**Problem Demonstration 3: Non-collocated 2 kW SDARS Interference Into WCS Cell 2 Miles Away (Theoretical)**

**Results: 8 % Reduction in Coverage Area of WCS CPE**

In Figure 6 the SDARS transmitter collocated with WCS base station ATL16WCS is turned on with an EIRP of 2 kW. This simulation again looks at the RF coverage area of WCS base station ATL04BST. The

WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The WCS cell coverage at this SDARS EIRP is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less.

- The areas colored by yellow and red are the areas where AGC does not work for intermodulation interference.
- The area colored in red is the area where AGC does not work for overload interference.

Because of the inability of the AGC to mitigate the interference, the WCS cell radius has been reduced to 1.2 to 6 miles with ***a loss in area covered of 8%***.

**Problem Demonstration 4: Combined Non-collocated SDARS Interference Into WCS Cell (Theoretical)**

**Results: 44 % Reduction in Coverage Area of WCS CPE**

In Figure 7 all fourteen SDARS transmitters are turned on. These SDARS EIRP levels are the levels stated in the XM and Sirius licensees' STA applications. This simulation again looks at the RF coverage area of WCS base station ATL04BST. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The WCS cell coverage at these SDARS EIRPs is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less.

- The areas colored by yellow and red are the areas where AGC does not work for intermodulation interference.
- The area colored in red is the area where AGC does not work for overload interference.

Because of the inability of the AGC to mitigate the interference, the WCS cell radius has been severely reduced with ***a loss in area covered of 44%***.

**Demonstration of Cell Coverage Without SDARS Interference**

Figure 8 shows the RF coverage area of WCS base station ATL08WCS that is located 8 miles from a non-transmitting SDARS site collocated with WCS base station ATL16WCS. The usable RF coverage includes the areas shown by the colors green and yellow. RF coverage varies from 3 to 6 miles.

**Problem Demonstration 5: Non-collocated 40 kW SDARS Interference Into WCS Cell 8 Miles Away (Theoretical)**

**Results: 1.2 % Reduction in Coverage Area of WCS CPE**

In Figure 9 the SDARS transmitter collocated with WCS base station ATL16WCS is turned on with an EIRP of 40 kW. This simulation again looks at the RF coverage area of WCS base station ATL08WCS. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The new WCS cell coverage is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less.

- The areas colored by yellow and red are the areas where AGC does not work for intermodulation interference.
- The area colored in red is the area where AGC does not work for overload interference.

Because of the inability of the AGC to mitigate the interference, the WCS cell radius has been reduced to 0 to 6 miles with ***a loss in area covered of 1.2%***.

Comparing the areas in Figures 4 and 9 where AGC does not work show that as the WCS cell is moved farther away from the SDARS repeater, the area where AGC does not work is reduced.

**Problem Demonstration 6: Non-collocated 7.3 kW SDARS Interference Into WCS Cell 8 Miles Away (Actual)**

**Results: 1.2 % Reduction in Coverage Area of WCS CPE**

In Figure 10 the SDARS transmitter collocated with WCS base station ATL16WCS is turned on with an EIRP of 7.3 kW. This SDARS EIRP is the level stated in the SDARS STA application. This simulation again looks at the RF coverage area of WCS base station ATL08WCS. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The WCS cell coverage at this SDARS EIRP is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less. The area colored by yellow is the area where AGC does not work for intermodulation interference. Because of the inability of the AGC to mitigate the interference, the WCS cell radius has been reduced to 0.8 to 6 miles with *a loss in area covered of 1.2%.*

**Problem Demonstration 7: Non-collocated 2 kW SDARS Interference Into WCS Cell 8 Miles Away (Theoretical)**

**Results: 1.2 % Reduction in Coverage Area of WCS CPE**

In Figure 11 the SDARS transmitter collocated with WCS base station ATL16WCS is turned on with an EIRP of 2 kW. This simulation again looks at the RF coverage area of WCS base station ATL08WCS. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The WCS cell coverage at this SDARS EIRP is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less. The area colored by yellow is the area where AGC does not work for intermodulation interference. Because of the inability of the AGC to mitigate the interference, the WCS cell radius has been reduced to 1.2 to 6 miles with *a loss in area covered of 1.2%.*

**Problem Demonstration 8: Combined Non-collocated SDARS Interference Into WCS Cell (Theoretical)**

**Results: 53 % Reduction in Coverage Area of WCS CPE**

In Figure 12 all fourteen SDARS transmitters are turned on. These SDARS EIRP levels are the levels stated in the SDARS licensees' STA applications. This simulation again looks at the RF coverage area of WCS base station ATL08WCS. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The WCS cell coverage at these SDARS EIRPs is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less.

- The areas colored by yellow and red are the areas where AGC does not work for intermodulation interference.
- The area colored in red is the area where AGC does not work for overload interference.

Because of the inability of the AGC to mitigate the interference, the WCS cell radius has been severely reduced with ***a loss in area covered of 53%.***

**Demonstration of Cell Coverage Without SDARS Interference**

Figure 13 shows the RF coverage area of WCS base station ATL16WCS that is collocated with a nontransmitting SDARS base station. The usable RF coverage includes the areas shown by the colors green and yellow. RF coverage varies from 5 to 6 miles.

**Problem Demonstration 9: Collocated 40 kW SDARS Interference Into WCS Cell (Theoretical)**

**Results: 100 % Reduction in Coverage Area of WCS CPE**

In Figure 14 the SDARS transmitter that is collocated with WCS base station ATL16WCS is turned on with an EIRP of 40 kW. This simulation again looks at the RF coverage area of WCS base station ATL16WCS. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The new WCS cell coverage is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less.

- The areas colored by yellow and red are the areas where AGC does not work for intermodulation interference.
- There is no area in the cell where the AGC solution works for intermodulation interference. The area colored in red is the area where AGC does not work for overload interference.

Because of the inability of the AGC to mitigate the interference, the WCS cell radius has been reduced to zero miles with ***a loss in area covered of 100%***.

**Problem Demonstration 10: Collocated 7.3 kW SDARS Interference Into WCS Cell (Actual)**

In Figure 15 the SDARS transmitter that is collocated with WCS base station ATL16WCS is turned on with an EIRP of 7.3 kW. This SDARS EIRP is the level stated in the SDARS STA application. This simulation again looks at the RF coverage area of WCS base station ATL16WCS. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The WCS cell coverage at this SDARS EIRP is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less. The areas colored by yellow and red are the areas where AGC does not work for intermodulation interference. The area colored in red is the area where AGC does not work for overload interference. There is essentially no area in the cell where the AGC solution works for intermodulation interference. Because of the inability of the AGC to mitigate the interference, the WCS cell radius has been reduced to zero miles with *a loss in area covered of 100%*.

**Problem Demonstration 11: Collocated 2 kW SDARS Interference Into WCS Cell (Theoretical)**

**Results: 98 % Reduction in Coverage Area of WCS CPE**

In Figure 16 the SDARS transmitter that is collocated with WCS base station ATL16WCS is turned on with an EIRP of 2 kW. This simulation again looks at the RF coverage area of WCS base station ATL16WCS. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The WCS cell coverage at this SDARS EIRP is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less.

- The areas colored by yellow and red are the areas where AGC does not work for intermodulation interference.
- The area colored in red is the area where AGC does not work for overload interference. There are very few areas in the cell where the AGC solution works.

Because of the inability of the AGC to mitigate the interference, the WCS cell radius has been essentially reduced to zero with ***a loss in area covered of 98%***.

**Problem Demonstration 12: Collocated 200 Watt SDARS Interference Into WCS Cell (Theoretical)**

**Results: 66 % Reduction in Coverage Area of WCS CPE**

In Figure 17 the SDARS transmitter that is collocated with WCS base station ATL16WCS is turned on with an EIRP of 200 watts. This simulation again looks at the RF coverage area of WCS base station ATL16WCS. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The WCS cell coverage at this SDARS EIRP is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less. The areas colored by yellow and red are the areas where AGC does not work for intermodulation interference.

Because of the inability of the AGC to mitigate the interference even at these SDARS levels, the WCS cell coverage is only spotty with ***a loss in area covered of 66%***.

**Problem Demonstration 13: Combined SDARS Interference Into WCS Cell (Theoretical)**

**Results: 100 % Reduction in Coverage Area of WCS CPE**

In Figure 18 all fourteen SDARS transmitters are turned. These SDARS EIRP levels are the levels stated in the SDARS licensees' STA applications. This simulation again looks at the RF coverage area of WCS base station ATL16WCS. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC. The WCS cell coverage at these SDARS EIRPs is shown by the colors blue, green and bluish green. These colors represent receive levels with a power gap of 20 dB or less.

- The areas colored by yellow and red are the areas where AGC does not work for intermodulation interference.
- The area colored in red is the area where AGC does not work for overload interference.

Because of the inability of the AGC to mitigate the interference, the WCS cell radius has been essentially reduced to zero with ***a loss in area covered of 100%***.

Conclusions from BellSouth Studies:

Reviewing the study results set forth above, the following conclusions can be made:

1. The RF front-end AGC solution does not work for WCS in most areas but may work in some selected areas.

2. The use of RF front-end AGC by WCS licensees comes with a penalty. That penalty is a reduction in cell size dictating the placement of additional cells to maintain the same coverage.

3. Power levels greater than 2 kW cause excessive coverage reduction.

## The WorldCom Study

WorldCom used computer modeling to determine the areas within a WCS market deployment where AGC cannot totally mitigate the affects of SDARS interference. The study was limited to 4 sites in WorldCom's Dallas/Ft Worth market where SDARS facilities are collocated, or in very close proximity.

The following parameters were used in the study:

1. The WCS base station transmit power (EIRP) was 126 watts.

2. WCS CPE antenna gain was 17 dB.

3. WCS CPE antenna height was 25 feet.

4. Minimum WCS receive signal level was –77 dBm (64QAM with a BER of $10^{-6}$).

5. Base Station coverage is a maximum of 7 miles.

6. The overload threshold level was –35 dBm at the receiver input.

7. The intermodulation threshold was –60 dBm at the receiver input.

8. The power gap for intermodulation interference was 17 dB.

9. The power gap for overload interference was 42 dB.

The EDX program calculated the difference between the WCS receive level and the SDARS receive level, i.e., carrier to interference (C/I) ratio, at all points in the study radius around WorldCom's sites. If the difference in power levels was more negative than –17B, the AGC solution could not mitigate the interference affects in that area for the two interference types under study. In the areas where the difference was –17 dB or higher, the AGC solution was successful in mitigating the interference problems of both types of interference.

The results of WorldCom's EDX modeling are shown in Figures 19 through 23.

Figures 19 through 22 depict a mapping in WorldCom's Dallas/Ft Worth market where the aggregate C/I of the XM and Sirius emitters in the Dallas/Ft Worth area are calculated against WorldCom's proposed WCS hub/booster sites. The EIRP of the SDARS emitters are in accordance with their FCC STA filings. WorldCom's downstream EIRP is conservatively assumed to be 21 dBW, although newer technology in CPE design promises to offer the possibility of much lower levels.

In Figure 19 the simulation looks at the RF coverage area of WCS base station DAL07. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC.

- The colors green and blue represent areas where the receive levels have a power gap of 17 dB or less. These areas are where the WCS system with AGC could mitigate any harmful interference. The SDARS base station does not cover most of the green and blue areas.
- The areas colored by yellow are the areas where AGC does not work for intermodulation interference.
- The areas colored in red are where the AGC does not work for overload interference. There is very little red area in this figure.

In Figure 20 the simulation looks at the RF coverage area of WCS base station FW002. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC.

- The colors green and blue represent areas where the receive levels have a power gap of 17 dB or less. These areas are where the WCS system with AGC could mitigate any harmful interference. The SDARS base stations do not cover most of the green and blue areas.
- The areas colored by yellow are the areas where AGC does not work for intermodulation interference.
- The areas colored in red are where the AGC does not work for overload interference. There is very little red area in this figure.

In Figure 21 simulation looks at the RF coverage area of WCS base station DAL08. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC.

- The colors green and blue represent areas where the receive levels have a power gap of 17 dB or less. These areas are where the WCS system does not receive any harmful interference. The SDARS base station does not cover most of the green and blue areas.
- The areas colored by yellow are the areas where AGC does not work for intermodulation interference.
- The areas colored in red are where the AGC does not work for overload. There is very little red area in this figure.

In Figure 22 the simulation looks at the RF coverage area of WCS base station DAL08. The WCS CPE in the WCS cell coverage area is equipped with RF front-end AGC.

- The colors green and blue represent areas where the receive levels have a power gap of 17 dB or less. These areas are where the WCS system with AGC could mitigate any harmful interference. The SDARS base station does not cover most of the green and blue areas.
- The areas colored by yellow are the areas where AGC does not work for intermodulation interference.
- The areas colored in red are where the AGC does not work for overload interference. There is very little red area in this figure.

Figure 23 depicts the C/I scenario if the collocated SDARS repeater at WorldCom site DAL08 was emitting at the maximum EIRP (46 dBW) requested in the SDARS FCC filings. The C/I power gap becomes much greater than 42 dB as shown by the additional red areas in the graphic. This example essentially means that a substantial part of the customer base served by the WorldCom site would be unserviceable at the high power authorizations requested by SDARS entities.

The foregoing C/I predictions are much more pessimistic if WorldCom's downstream EIRP is lowered to a power level in the range of 6 dBW, as suggested by new vendor equipment designs.

Conclusions from WorldCom's Studies:

XM Radio's description of its use of AGC in customer premise equipment (CPE) provides an interesting concept for mitigating interference to CPE. But it does not provide a viable solution for the predicted interference to WorldCom CPE from terrestrial SDARS repeaters.

SDARS repeaters that are allowed to emit at EIRP levels to 40 kW cause irreparable interference to WCS CPE.

## High Power Versus Low Power Repeaters

On page seventeen of the XM's supplement, XM comments on replacing high power repeaters with many low power repeaters. BellSouth/WorldCom respond as follows:

> The EIRP limitations placed on base stations in most services apply to any radial emanating from the base station antennas. Therefore a 2 kW limit means that along any radial, the maximum EIRP cannot exceed 2 kW. XM's comparison of the exclusion zones from omni and sectored sites misses the point. If XM decided to switch from omni sites at 2 kW to sectored sites, this implies that the proper design for the application initially was sectored sites. To use an omni site to cover an area better handled by a sectored site is poor engineering. Since the appropriate antenna selection was for a sectored antenna, the comparison should be between a 2 kW-sectored site and a higher powered sectored site. The higher power site's exclusion zone would, of course, be larger.
>
> Considering the above, we disagree with XM's argument on high-power versus low-power repeaters but realize that this is a topic that should be addressed in the ongoing rulemaking process.
>
> Further, XM's filing shows that the real reason it wants high-powered repeaters is that it solves *ITS* self- interference problem. Again, XM fixes its own problems at the expense of WCS operators.

## Summary

A summary of the results of the BellSouth study of WCS cell coverage loss due to a single SDARS interferer is shown in the table below.

### Summary of Results – WCS Cell Coverage Loss With Single Interferer

| WCS Base Station Location Relative to SDARS Repeater | Coverage Loss with SDARS Repeater EIRP at 40KW | Coverage Loss with SDARS Repeater EIRP at 7.3KW | Coverage Loss with SDARS Repeater EIRP at 2KW | Coverage Loss with SDARS Repeater EIRP at 0.2KW |
|---|---|---|---|---|
| Collocated | 100% | 100% | 98% | 63% |
| 2-mile Separation | 41% | 22% | 8% | |
| 8-mile Separation | 1.2% | 1.2% | 1.2% | |

The above table shows that for collocated situations, reducing SDARS' EIRP does not work even with XM's AGC fix. For situations where the WCS base station is 2 miles from a SDARS repeater, reducing SDARS' EIRP reduces WCS cell coverage loss dramatically. For situations where the WCS base station is 8 miles from a SDARS repeater, WCS cell coverage loss is minimal.

A summary of the results of the BellSouth study of WCS cell coverage loss due to multiple SDARS interferers is shown in the table below.

### Atlanta Example – WCS Cell Coverage Loss With Multiple Interferers

| | Collocated Base Stations | WCS Base Station 0.5 Miles from Nearest SDARS Repeater | WCS Base Station 2 miles from Nearest SDARS Repeater |
|---|---|---|---|
| Coverage Loss of WCS Cell with all SDARS Repeaters' EIRP at STA Stated Levels | 100% | 54% | 45% |

The above table shows that coverage loss of WCS service area, within a SDARS interference environment depends on the relative location of the WCS base station to all SDARS' repeaters. This study was carried out assuming all SDARS repeater's EIRPs were at the stated STA levels. The table also shows that the loss impact cannot be ignored even when a WCS base station is, at least, 2 miles away from any surrounding SDARS' repeaters. In the Atlanta market 58 % of the service area is within two miles of a SDARS repeater.

For the WorldCom study, the coverage loss of WCS service area ranges from 30 to 40 %.

In addition the BellSouth and WorldCom studies show that the magnitude of the interference impact is influenced by the difference in power levels between the SDARS transmitter and the WCS transmitter. When the power level difference is large, the magnitude of the cell coverage loss is high, and when the power level difference is small, the cell coverage loss is less. However, resolution of interference issues should not be based on the system characteristics of any one technology at any point in time, but should be resolved in such a way as to continue to preserve the flexible nature of the WCS spectrum.

Even though the studies show that 2 kW SDARS repeaters impact WCS deployments, the WCS licensees have already acknowledged the likelihood that the SDARS licensees will be permitted unlimited deployment of 2 kW repeaters. From the above discussions, it is also clear that XM's proposal may solve some of the problems that it creates but not all.

Further the WCS licensees demonstrate conclusively that the interference solutions proposed by XM will not provide an adequate solution to the harmful interference caused by their high-powered SDARS repeaters. Indeed, XM's solutions create **additional** problems for WCS licensees in the form of decreased system's performance and coverage.

The WCS licensees' services are two-way data services that are far different from the one-way SDARS' broadcast services. In a WCS system, the CPE is as equally important as its base stations and, therefore, deserves equal protection.

These are the *specific reasons* why granting the licenses proposed by the SDARS operators will cause harmful interference and economic damage to WCS licensees. Accordingly, the Commission should not permit the operation of SDARS terrestrial repeaters at levels above 2 kW EIRP.

## Table 1 Results of Calculations of AGC Proposed Solution

| SDARS EIRP (WATTS) | WCS EIRP (WATTS) | WCS CELL SIZE (MI) | WCS RCVR DISTANCE FROM BS (MI) | SDARS INTERFERING PATH LENGTH (MI) | WCS RECEIVE LEVEL (dBm) | WCS EXCESS LINK MARGIN (dB) | SDARS LEVEL AT WCS RECEIVER (dBm) | DIFFERENCE BETWEEN SDARS LEVEL AND WCS LEVELS | AGC WORKS FOR OVERLOAD WITHOUT IMPACTING WCS PERFORMANCE? | AGC WORKS FOR IM WITHOUT IMPACTING WCS PERFORMANCE? |
|---|---|---|---|---|---|---|---|---|---|---|
| 40,000 | 3.6 | 5 | 5 | 5 | -80 | 0 | -25 | 55 | NO | NO |
| | | 5 | 2 | 2 | -68 | 12 | -17 | 51 | NO | NO |
| | | 5 | 1 | 1 | -59 | 21 | -11 | 48 | NO | NO |
| | | 5 | 5 | 15 | -80 | 0 | -34.5 | 45.5 | NO | NO |
| | | 5 | 1 | 11 | -59 | 21 | -31.5 | 27.5 | YES | NO |
| | | 5 | 5 | 65 | -80 | 0 | -47.2 | 32.8 | YES | NO |
| | | 5 | 2 | 62 | -68 | 12 | -46.8 | 21.2 | YES | NO |
| | | 5 | 1 | 61 | -59 | 21 | -46.7 | 12.3 | YES | YES |
| | | 5 | 5 | 75 | -80 | 0 | -48.5 | 31.5 | YES | NO |
| | | 5 | 3 | 73 | -74 | 6 | -48.2 | 25.8 | YES | NO |
| | | 5 | 2 | 72 | -68 | 12 | -48.1 | 19.9 | YES | YES |
| | | 5 | 5 | 285 | -80 | 0 | -60.1 | 19.9 | YES | YES |
| 20,000 | 3.6 | 5 | 5 | 5 | -80 | 0 | -27.9 | 52.1 | NO | NO |
| | | 5 | 2 | 2 | -68 | 12 | -20 | 48 | NO | NO |
| | | 5 | 1 | 1 | -59 | 21 | -14 | 45 | NO | NO |
| | | 5 | 5 | 15 | -80 | 0 | -37.5 | 42.5 | YES | NO |
| | | 5 | 5 | 65 | -80 | 0 | -50.2 | 29.8 | YES | NO |
| | | 5 | 2 | 62 | -68 | 12 | -49.8 | 18.2 | YES | YES |
| | | 5 | 5 | 205 | -80 | 0 | -60.2 | 19.8 | YES | YES |
| 10,000 | 3.6 | 5 | 5 | 5 | -80 | 0 | -30.9 | 49.1 | NO | NO |
| | | 5 | 2 | 2 | -68 | 12 | -23 | 45 | NO | NO |
| | | 5 | 1 | 1 | -59 | 21 | -17 | 42 | YES | NO |
| | | 5 | 5 | 65 | -80 | 0 | -53.2 | 26.8 | YES | NO |
| | | 5 | 2 | 62 | -68 | 12 | -52.8 | 15.2 | YES | YES |
| | | 5 | 5 | 145 | -80 | 0 | -60.2 | 19.8 | YES | YES |
| 5,000 | 3.6 | 5 | 5 | 5 | -80 | 0 | -33.9 | 46.1 | NO | NO |
| | | 5 | 2 | 2 | -68 | 12 | -26 | 42 | YES | NO |
| | | 5 | 5 | 15 | -80 | 0 | -43.5 | 36.5 | YES | NO |
| | | 5 | 1 | 11 | -59 | 21 | -40.8 | 18.2 | YES | YES |
| | | 5 | 5 | 105 | -80 | 0 | -60.4 | 19.6 | YES | YES |
| 2,000 | 3.6 | 5 | 5 | 5 | -80 | 0 | -37.9 | 42.1 | YES | NO |
| | | 5 | 1 | 1 | -59 | 21 | -24 | 35 | YES | NO |
| | | 5 | 5 | 15 | -80 | 0 | -43.5 | 36.5 | YES | NO |
| | | 5 | 1 | 11 | -59 | 21 | -44.8 | 14.2 | YES | YES |
| | | 5 | 5 | 65 | -80 | 0 | -60.2 | 19.8 | YES | YES |

## Figure 1 AGC Power Gap Requirement

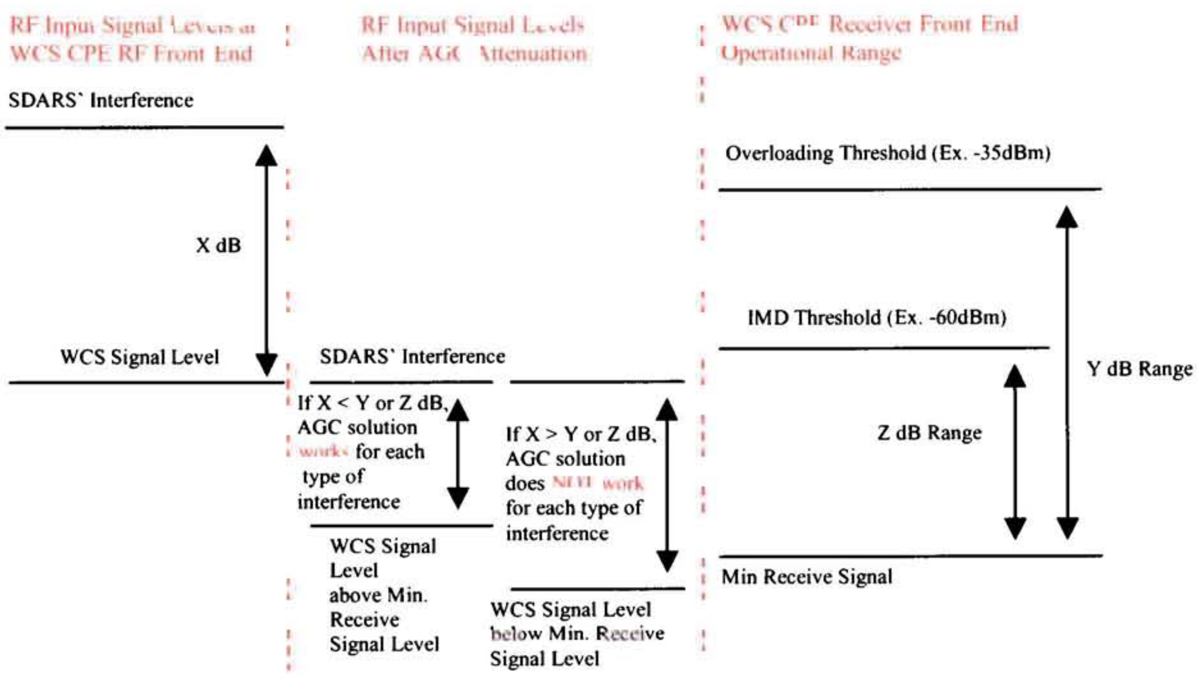
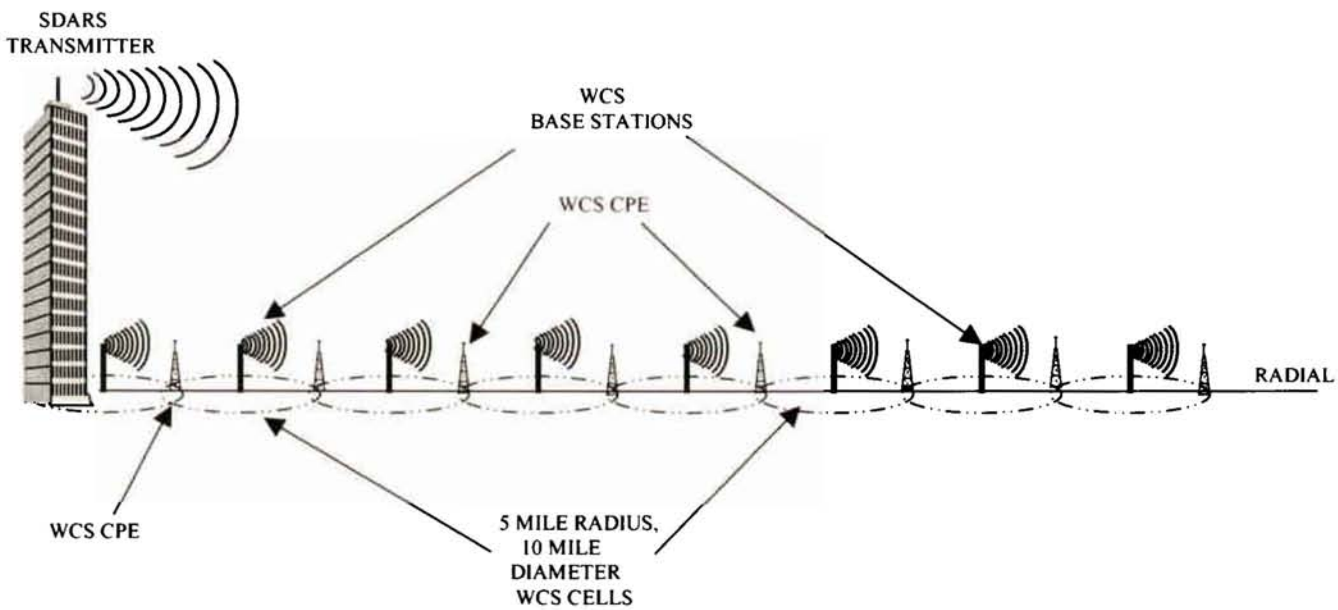
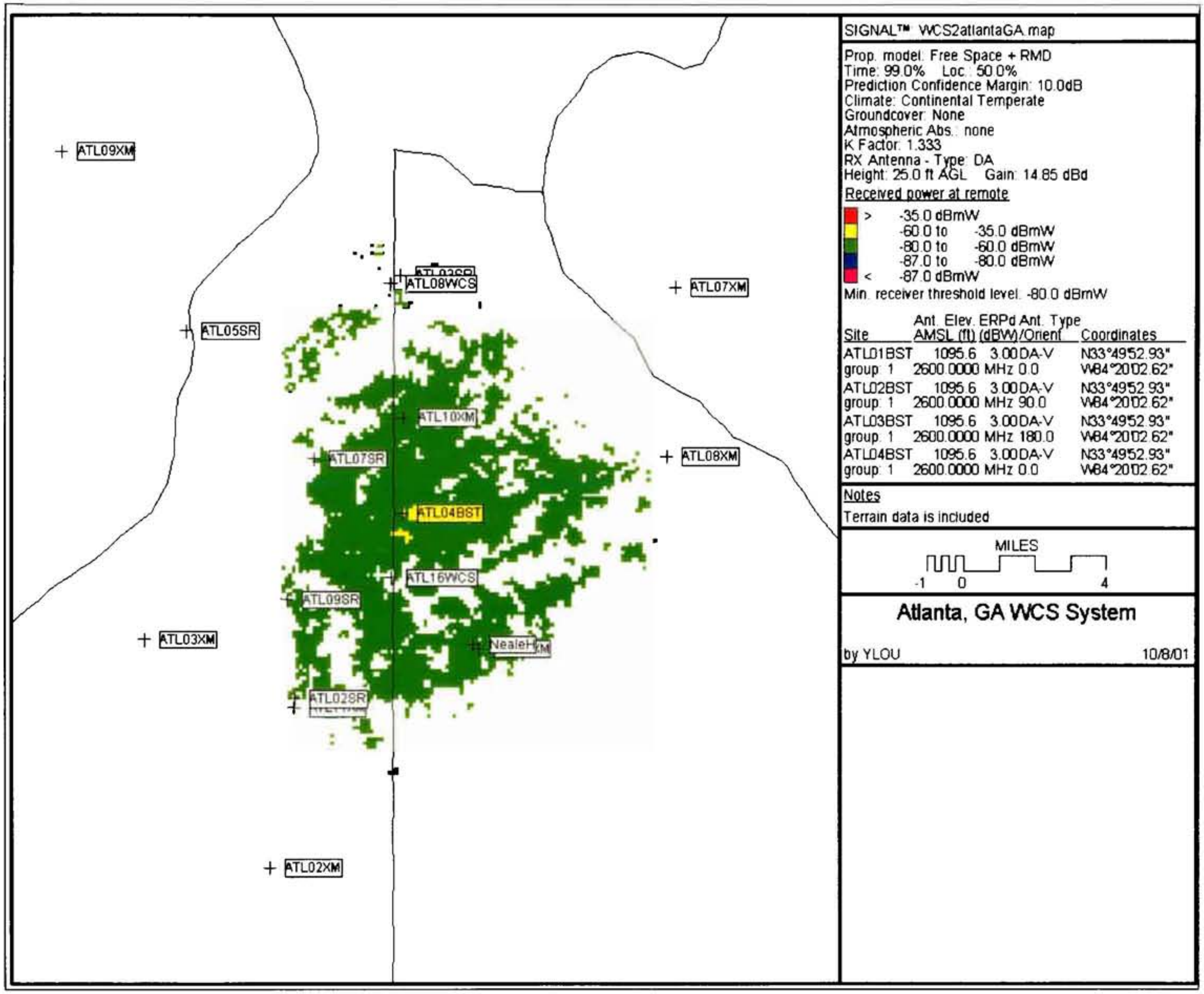


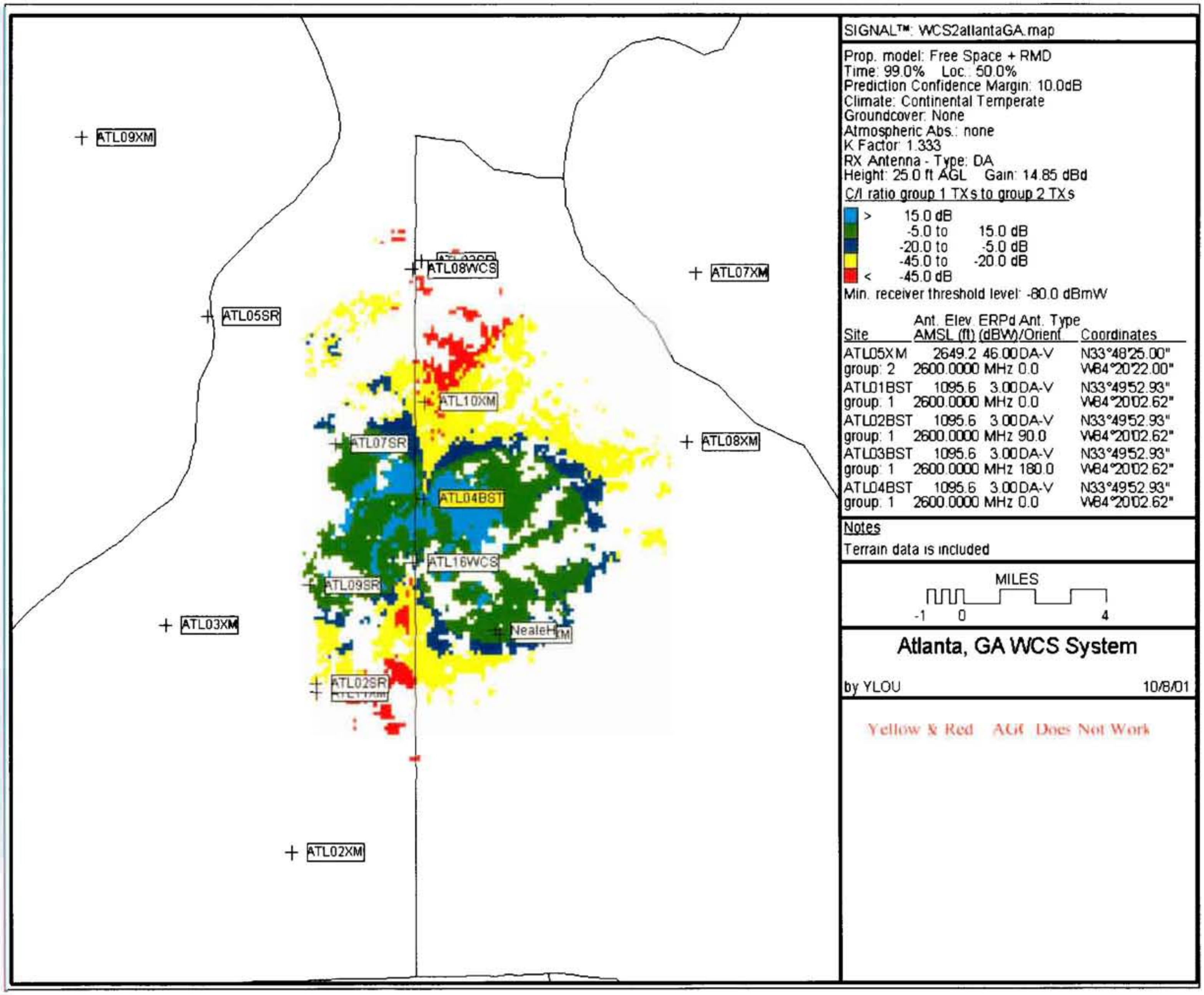
**Figure 2 Radial Layout For AGC Calculation**



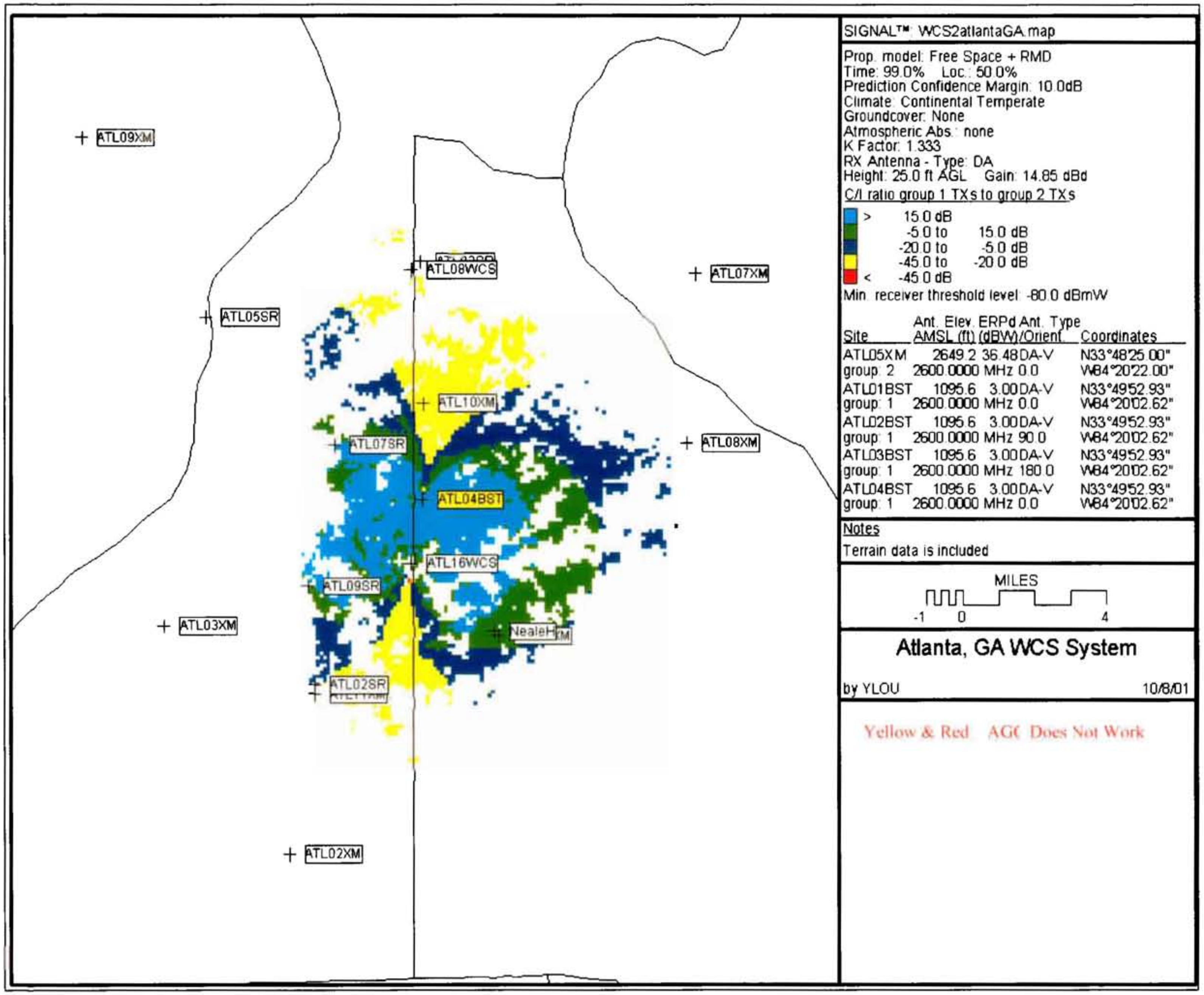
# Figure 3
# RF Coverage from WCS Base Station at 2W



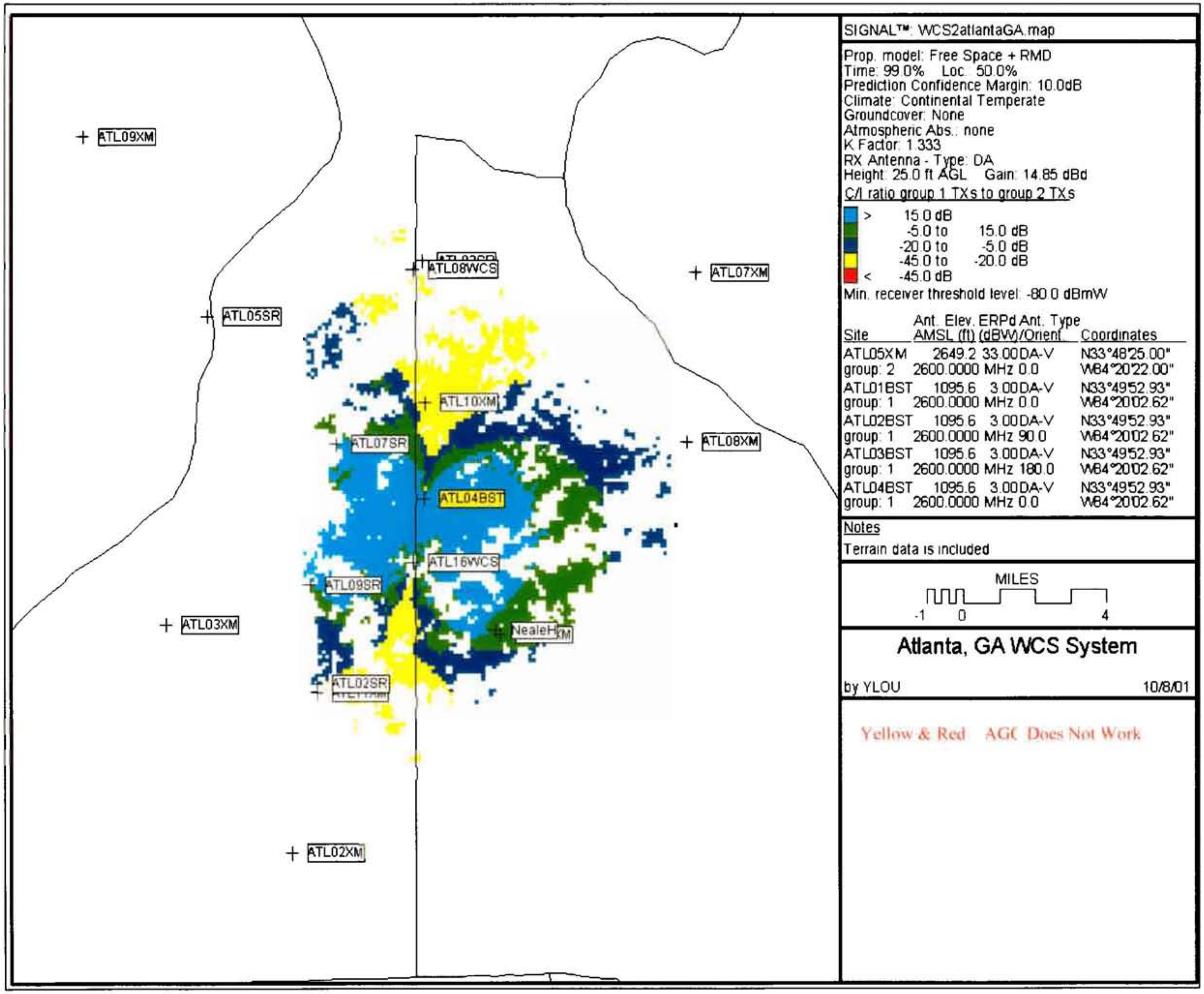
# Figure 4
# SDARS (at 40KW) Interference to WCS System



# Figure 5
# SDARS Repeater at 7.3KW (Original Design) Interference to WCS System

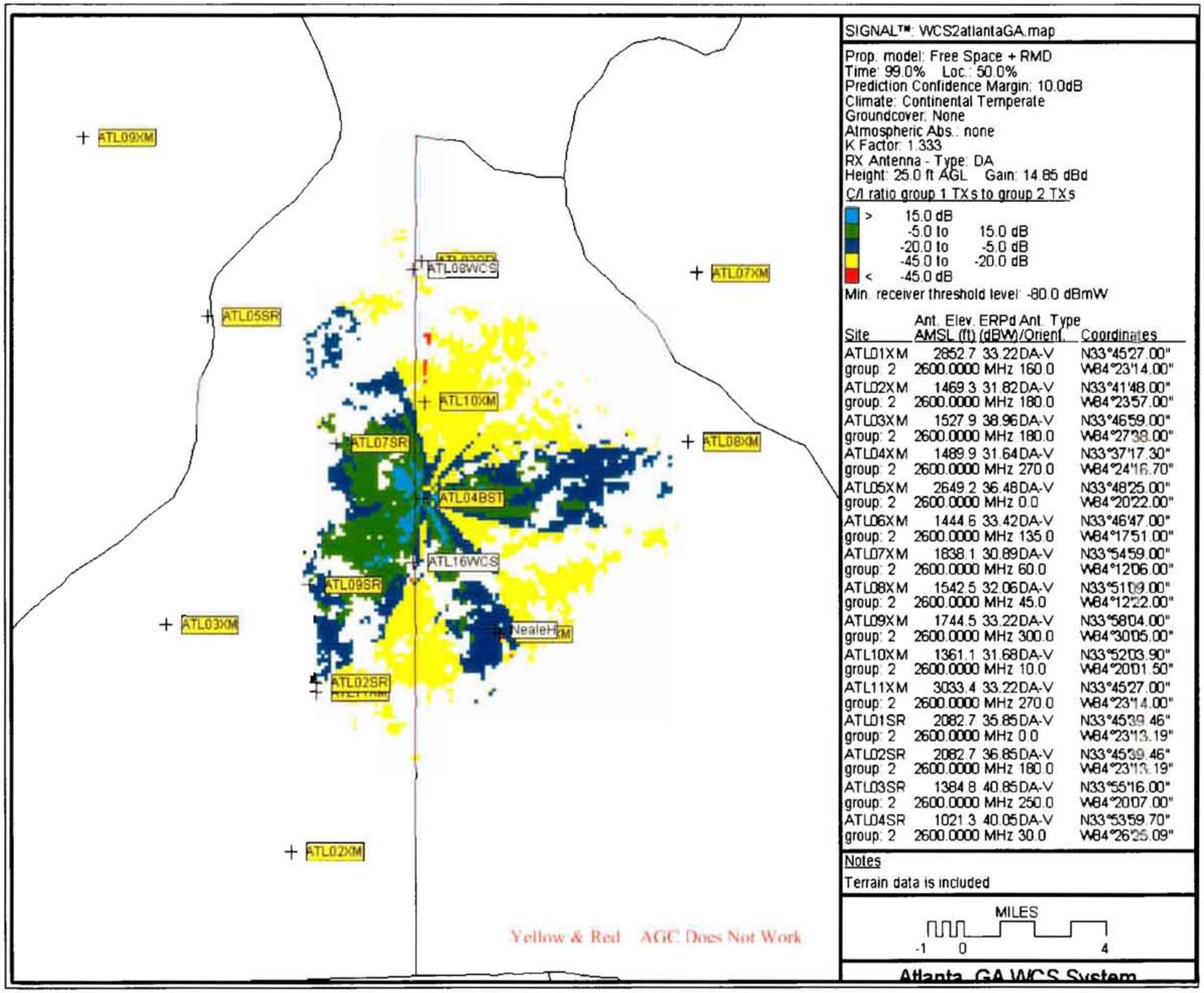


# Figure 6
# SDARS Repeater at 2KW Interference to WCS System

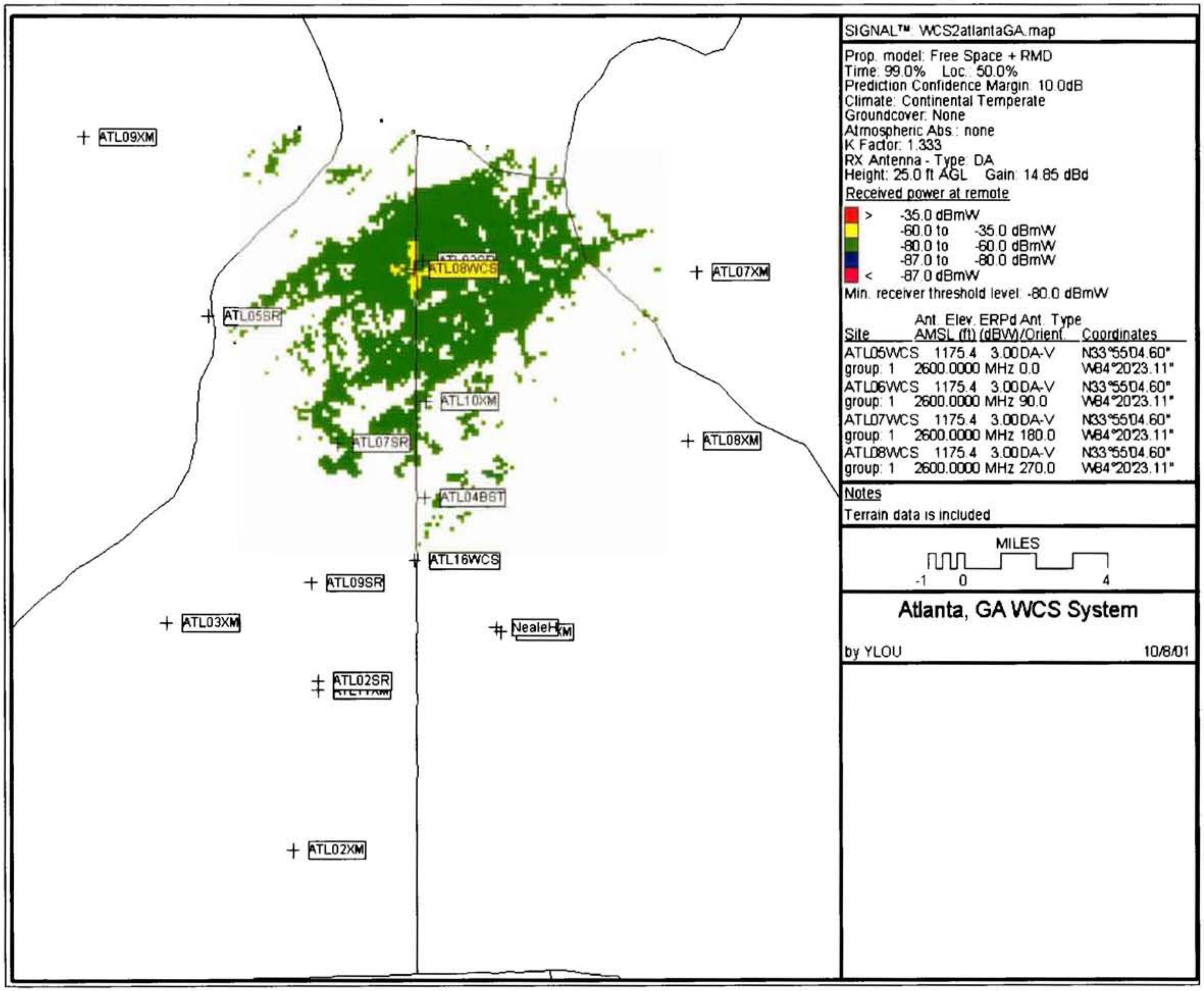


# Figure 7

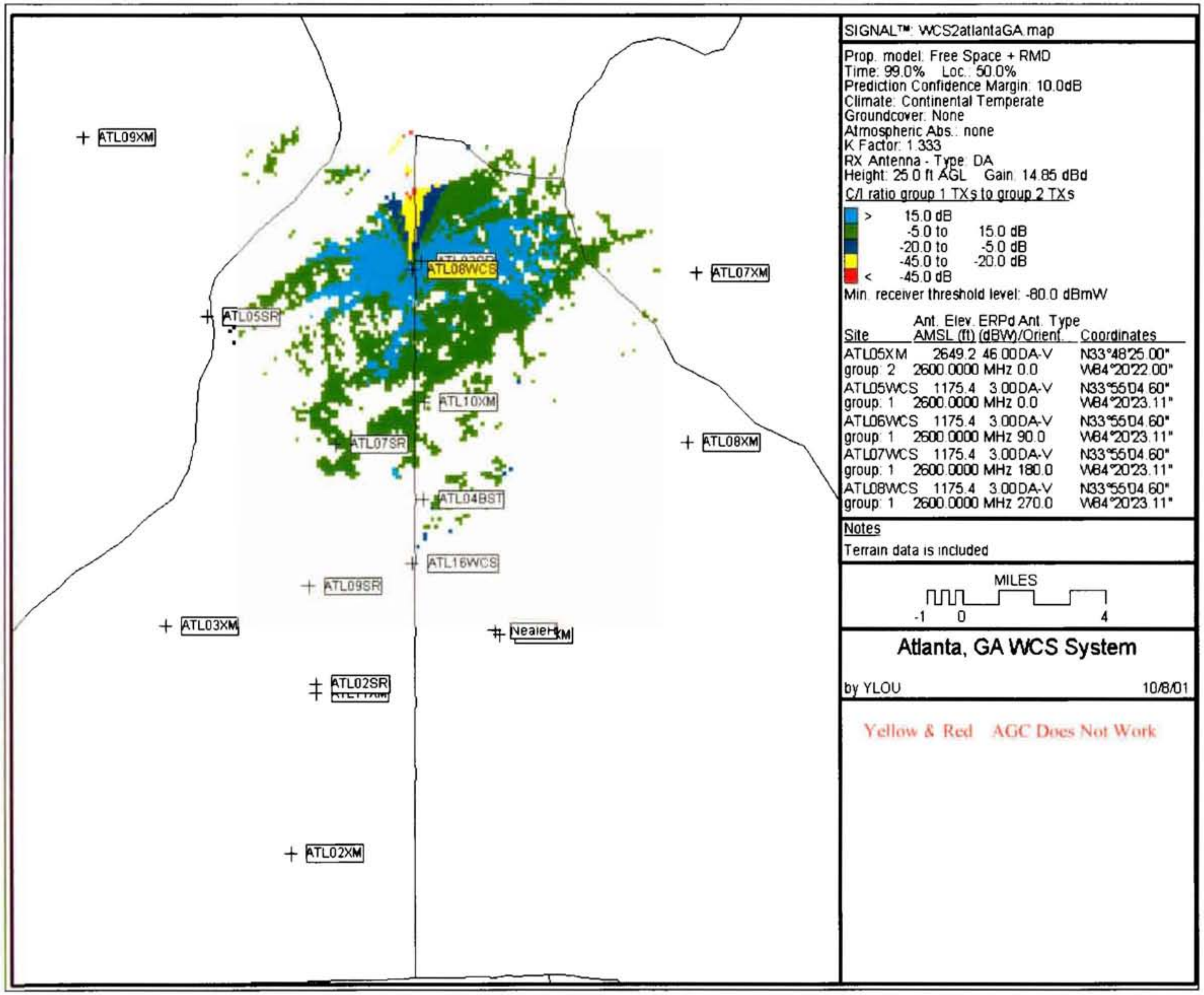
## WCS Site (~ 2Miles Away from ATL05XM) Coverage under Interference from All SDARS in STA



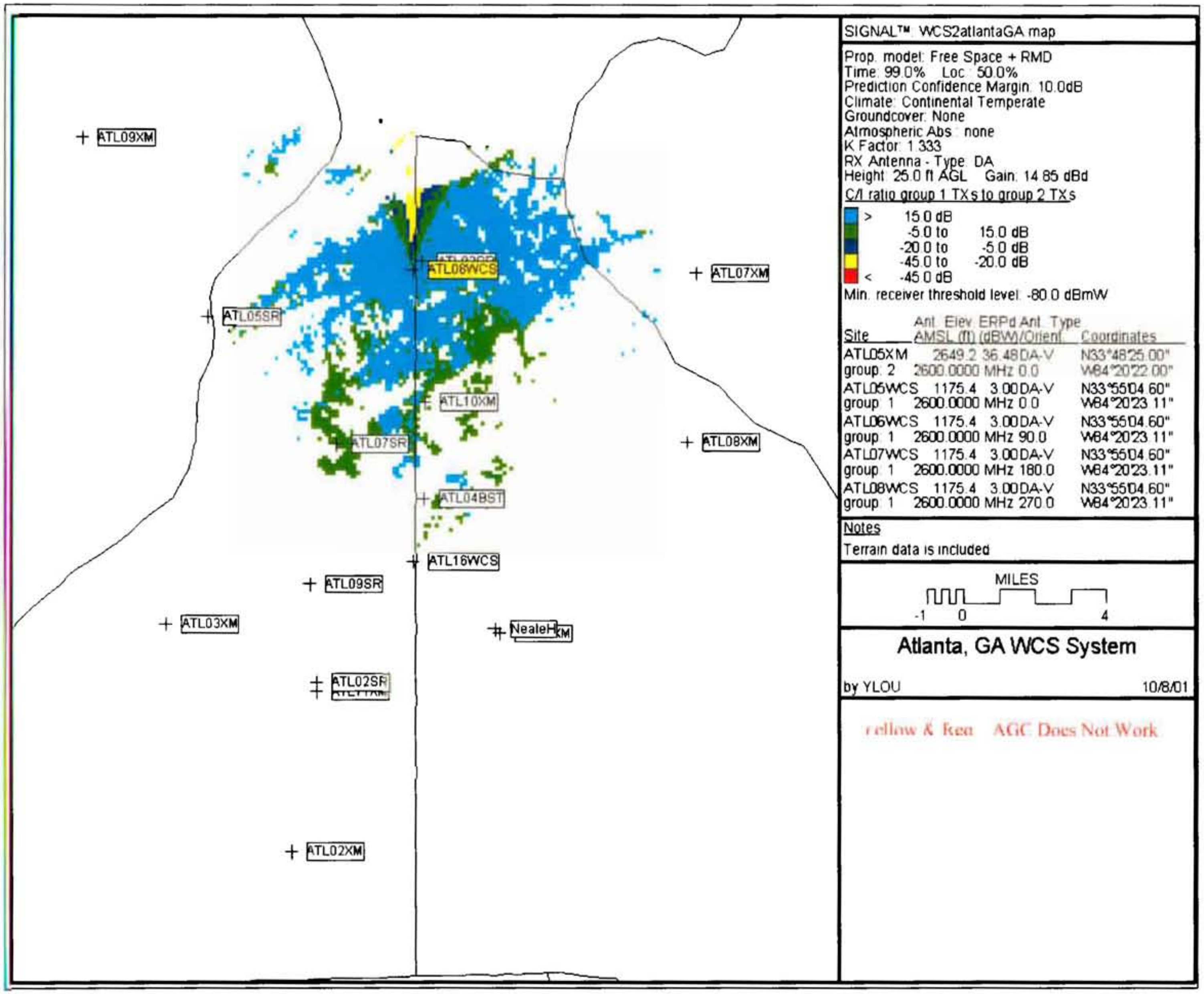
# Figure 8
# RF Coverage from WCS Base Station at 2W



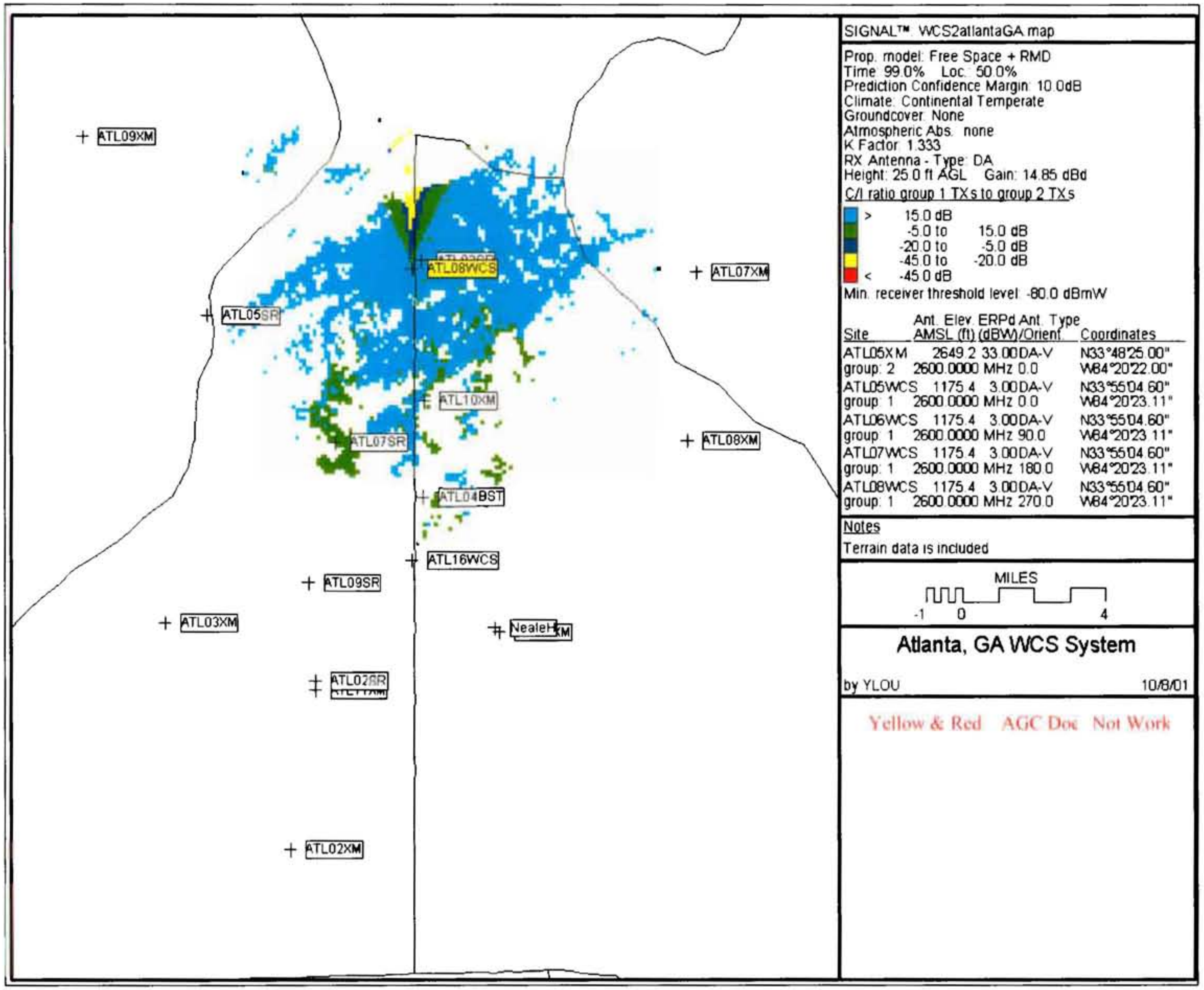
# Figure 9
# SDARS (at 40KW) Interference to WCS System



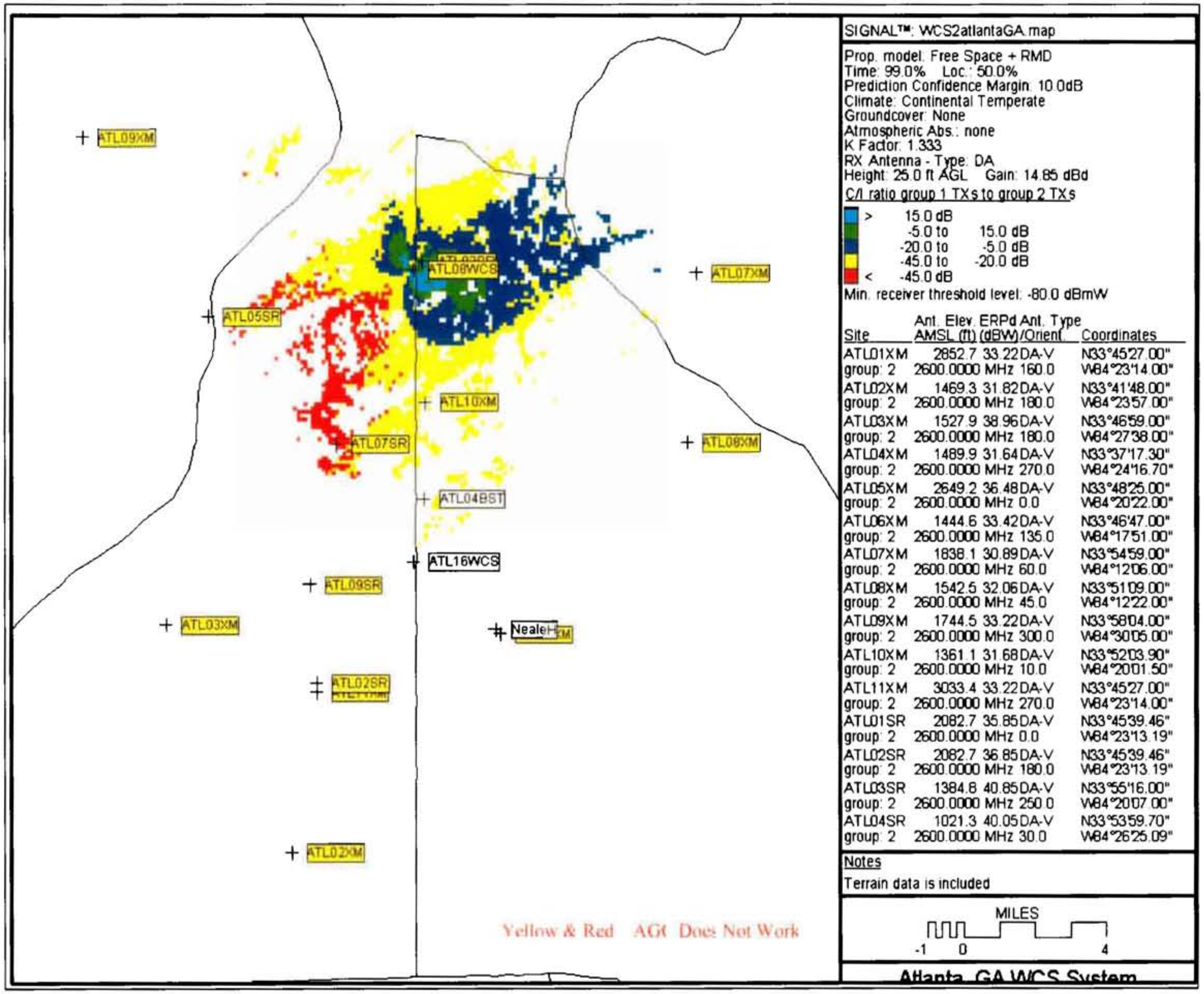
# Figure 10
# SDARS Repeater at 7.3KW (Original Design) Interference to WCS System



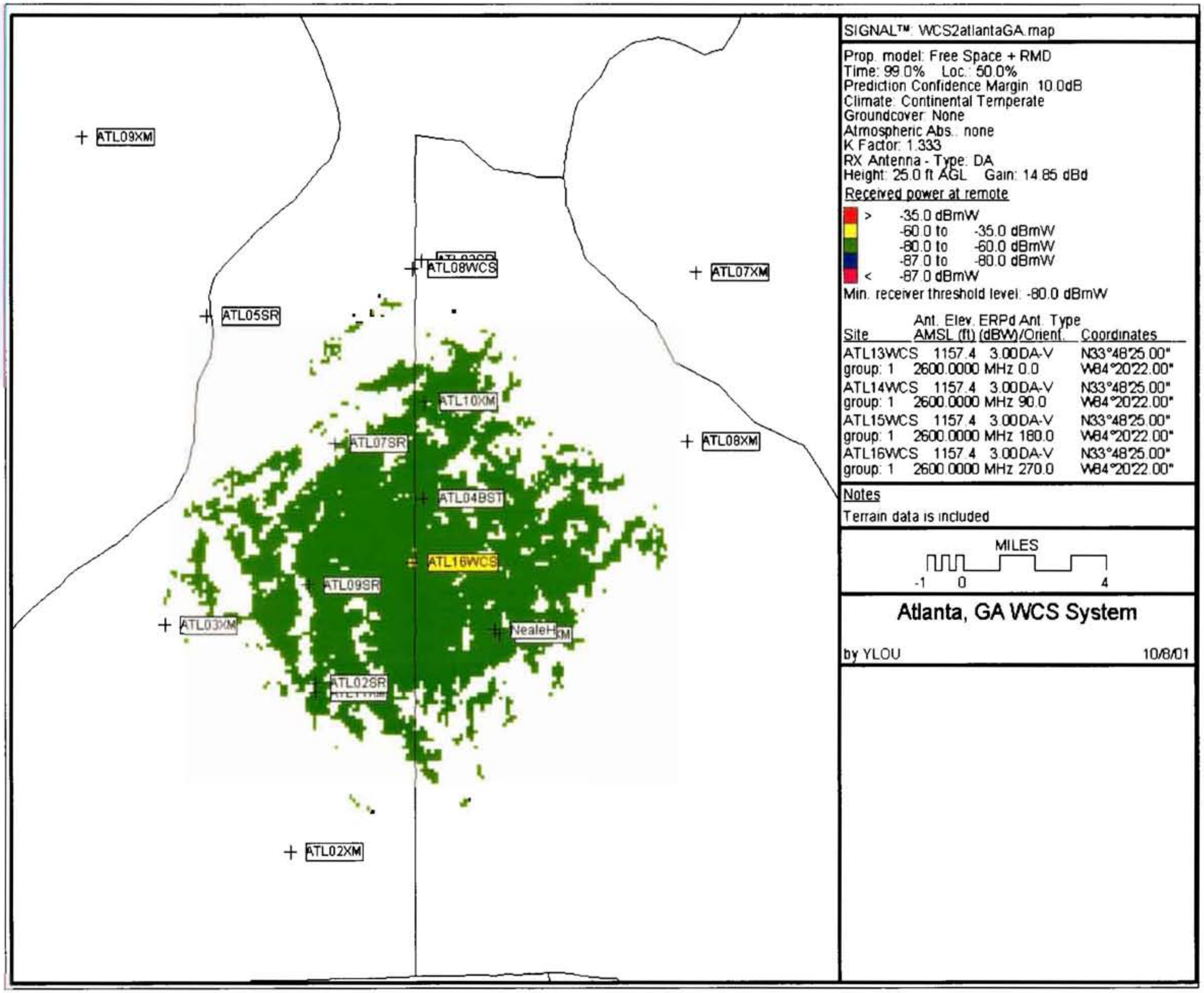
# Figure 11
# SDARS Repeater at 2KW Interference to WCS System



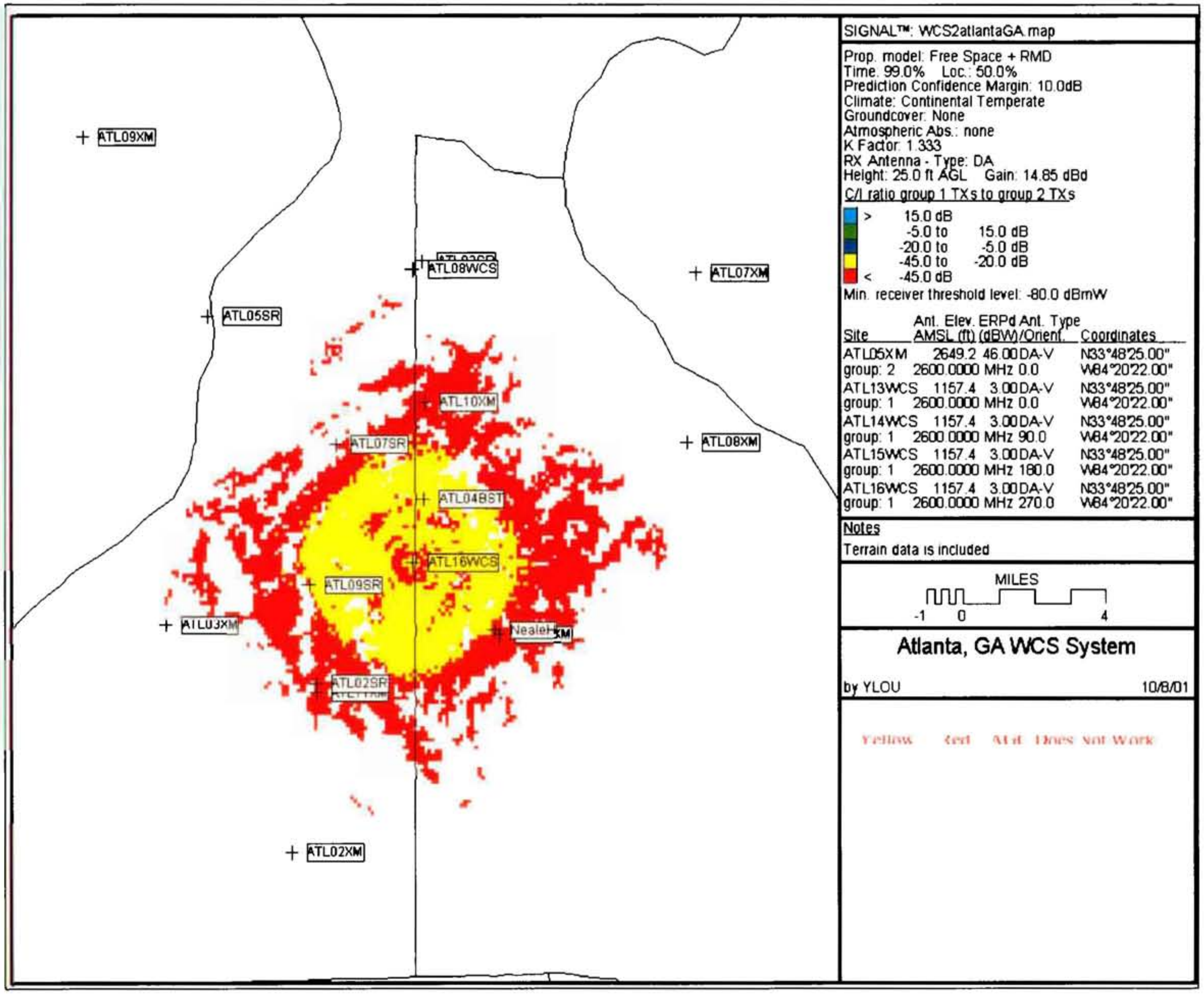
# Figure 12
## WCS Site (~ 8 Miles Away from ATL05XM) Coverage under Interference from All SDARS in STA



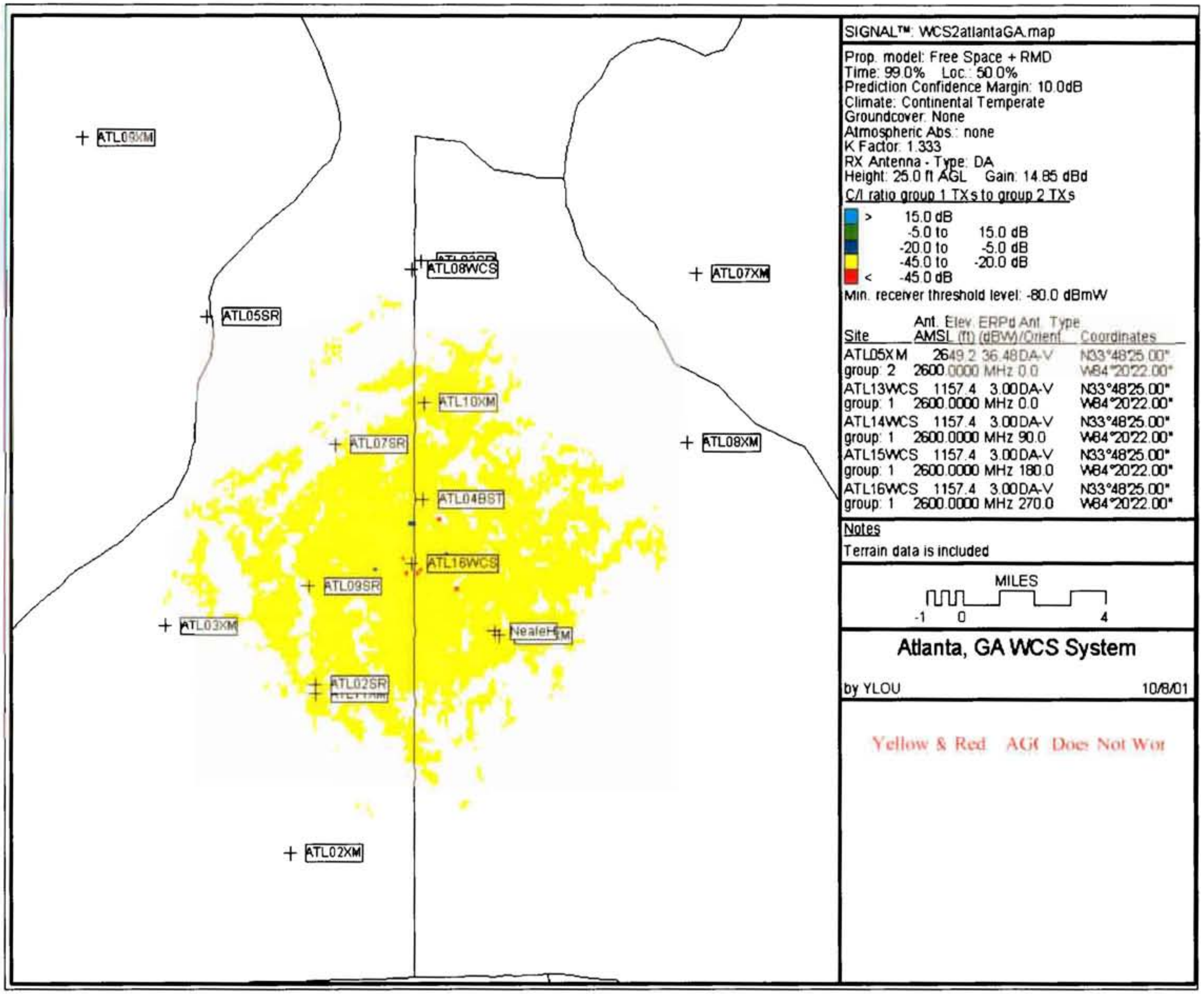
# Figure 13
# RF Coverage from WCS Base Station at 2W



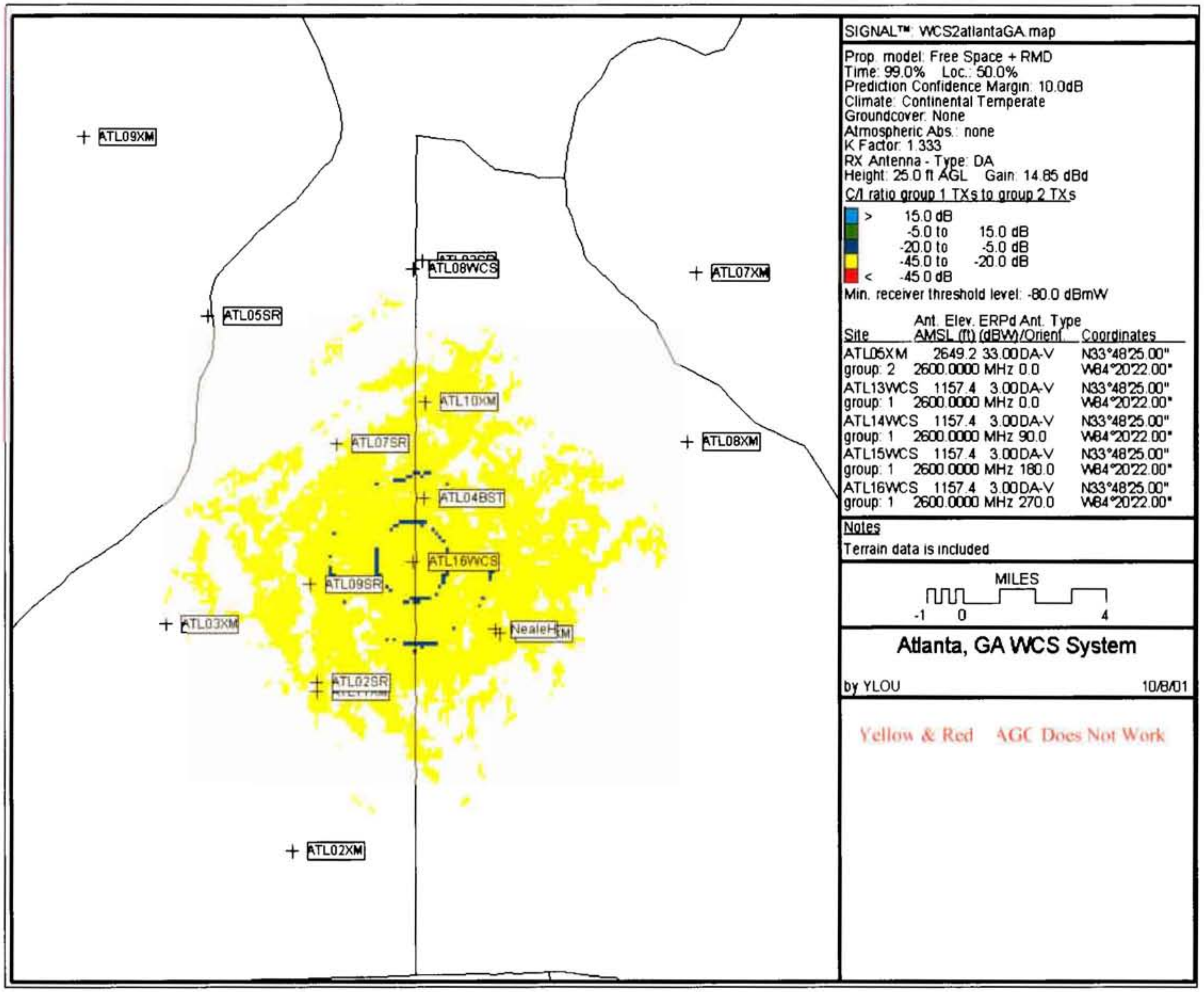
# Figure 14
# SDARS (at 40KW) Interference to WCS System



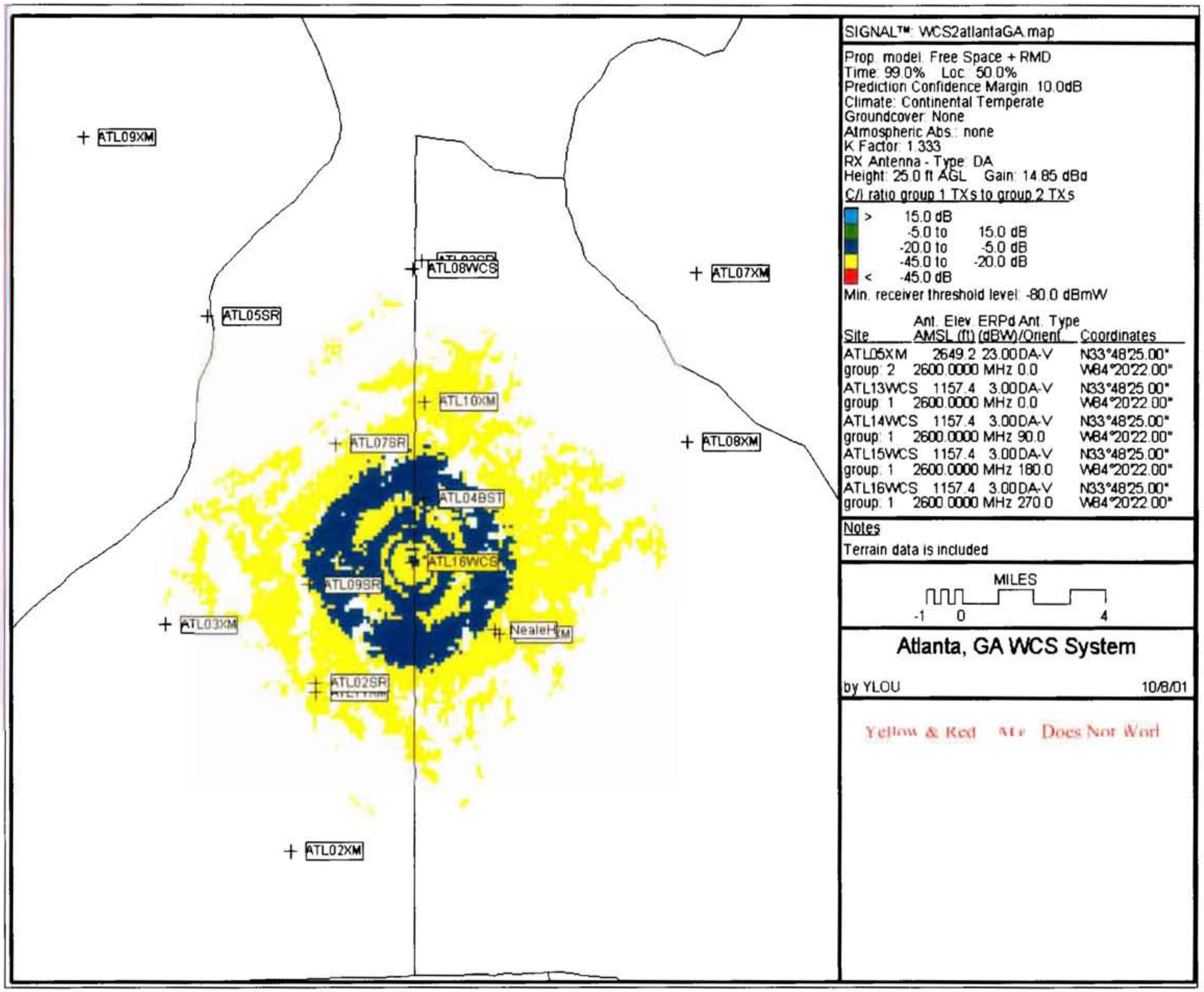
# Figure 15
## SDARS Repeater at 7.3KW (Original Design) Interference to WCS System



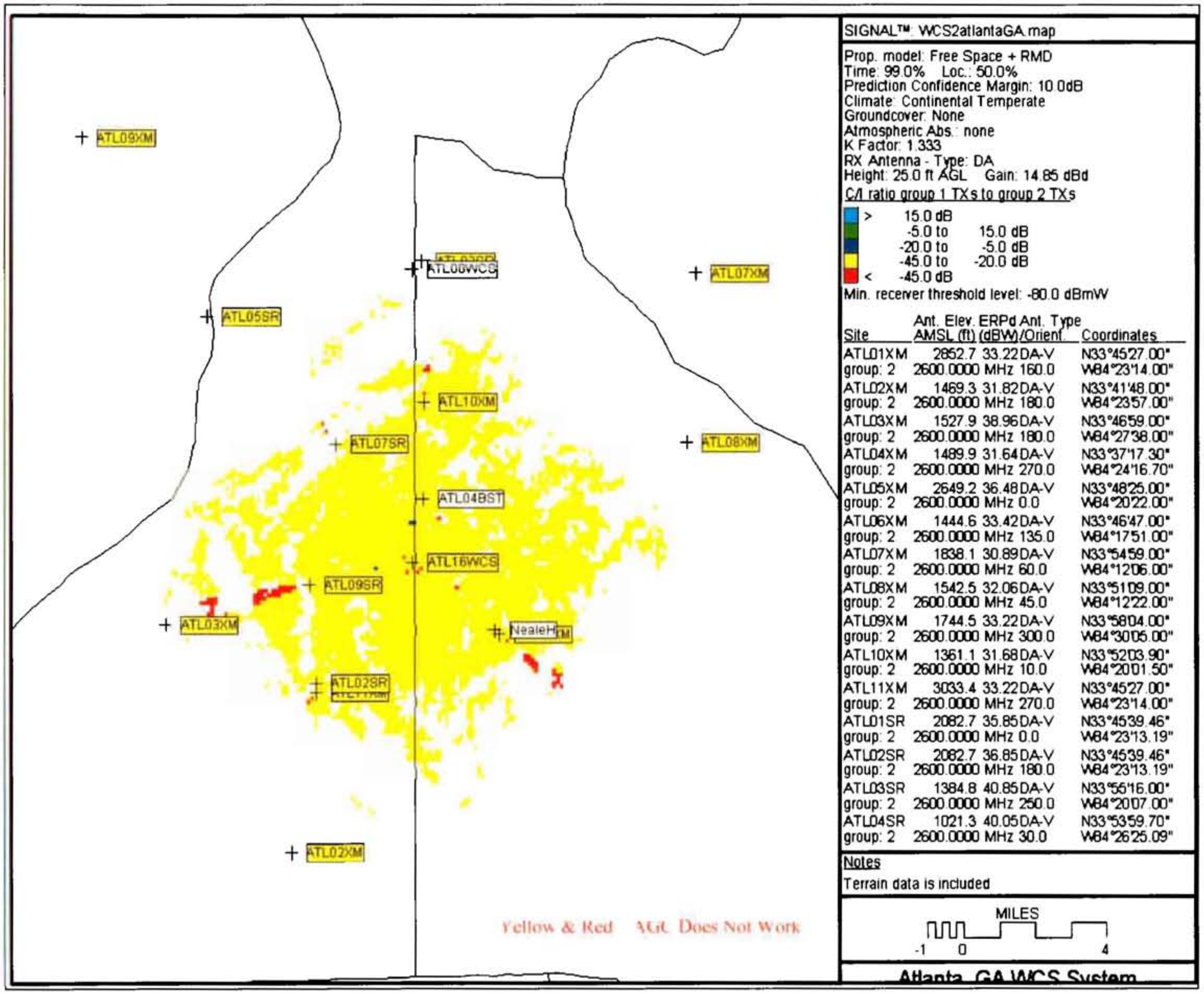
## Figure 16
## SDARS Repeater at 2KW Interference to WCS System



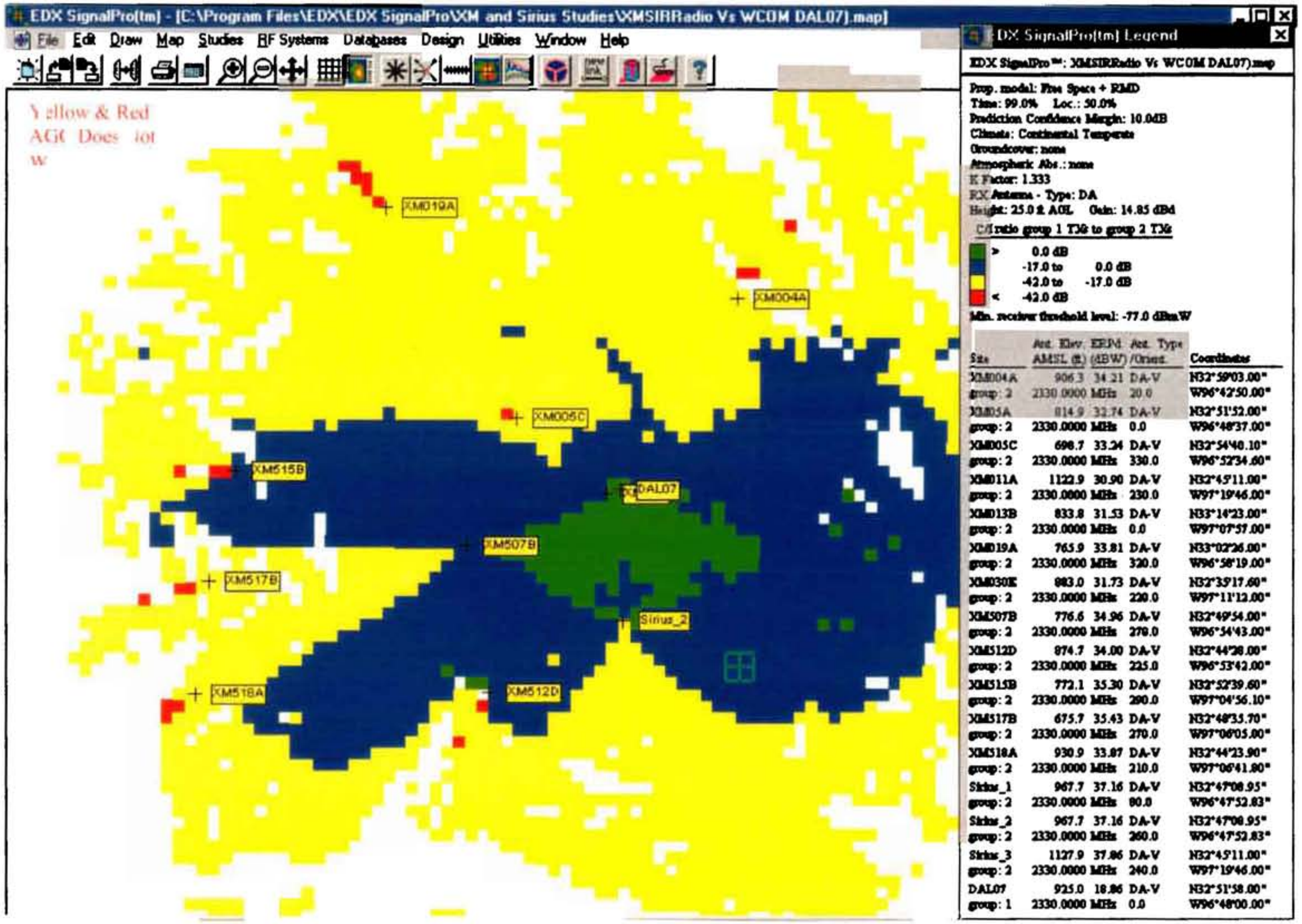
# Figure 17
# SDARS Repeater at 200W Interference to WCS System



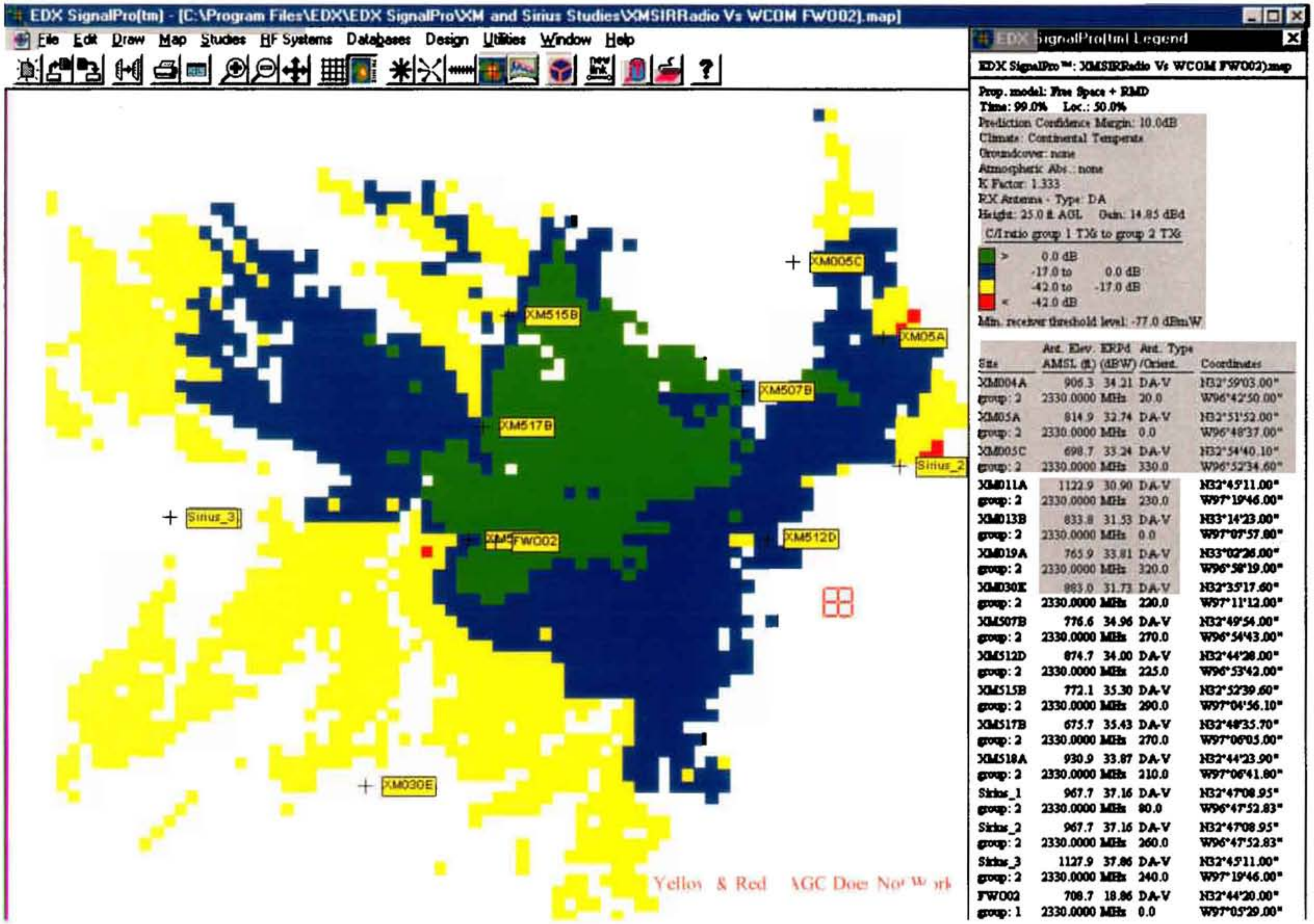
# Figure 18
# WCS Site (Collocated with ATL05XM) Coverage under Interference from All SDARS in STA



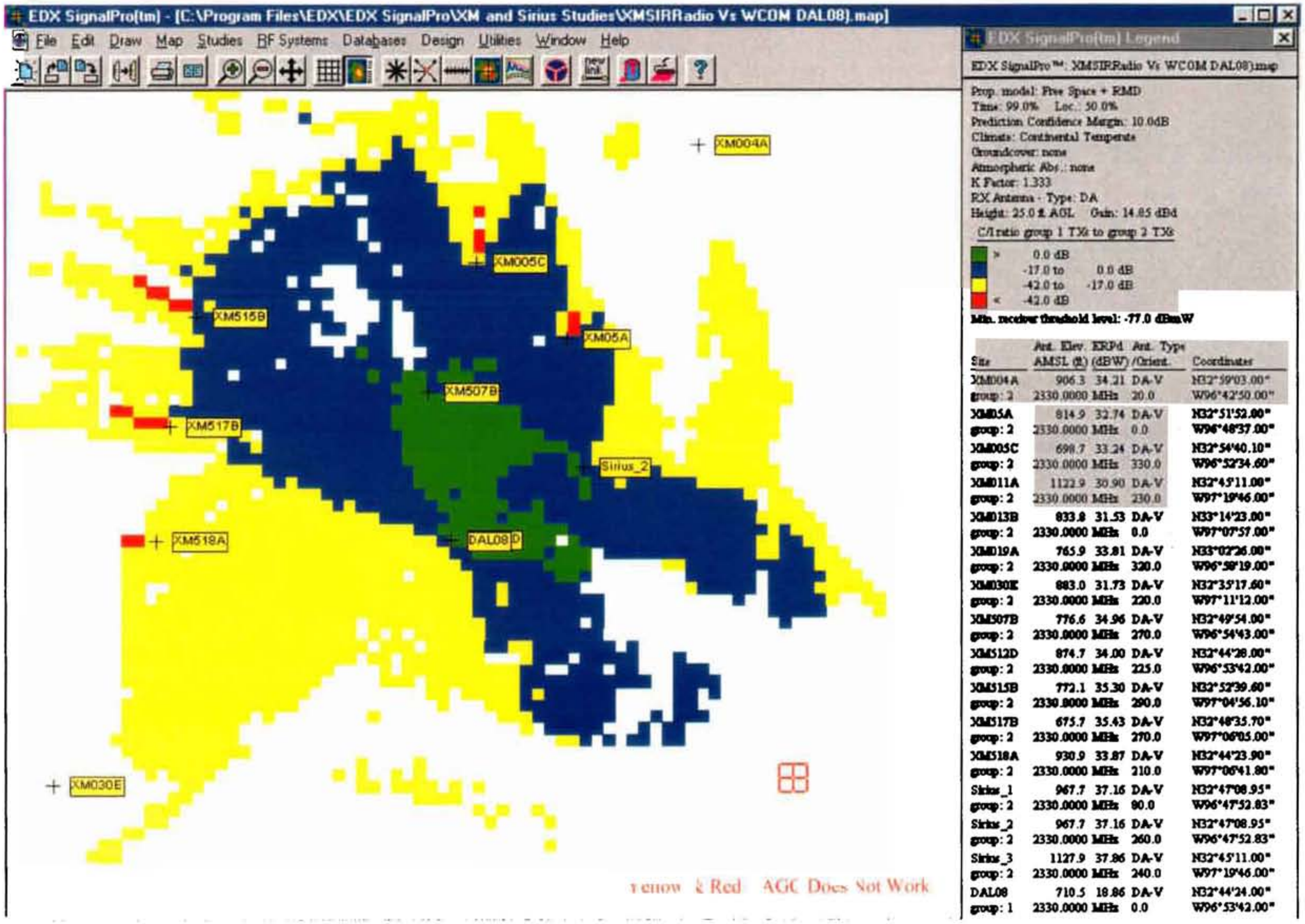
# Figure 19
# SDARS (XM & SIRIUS) Vs. WorldCom (DAL07)



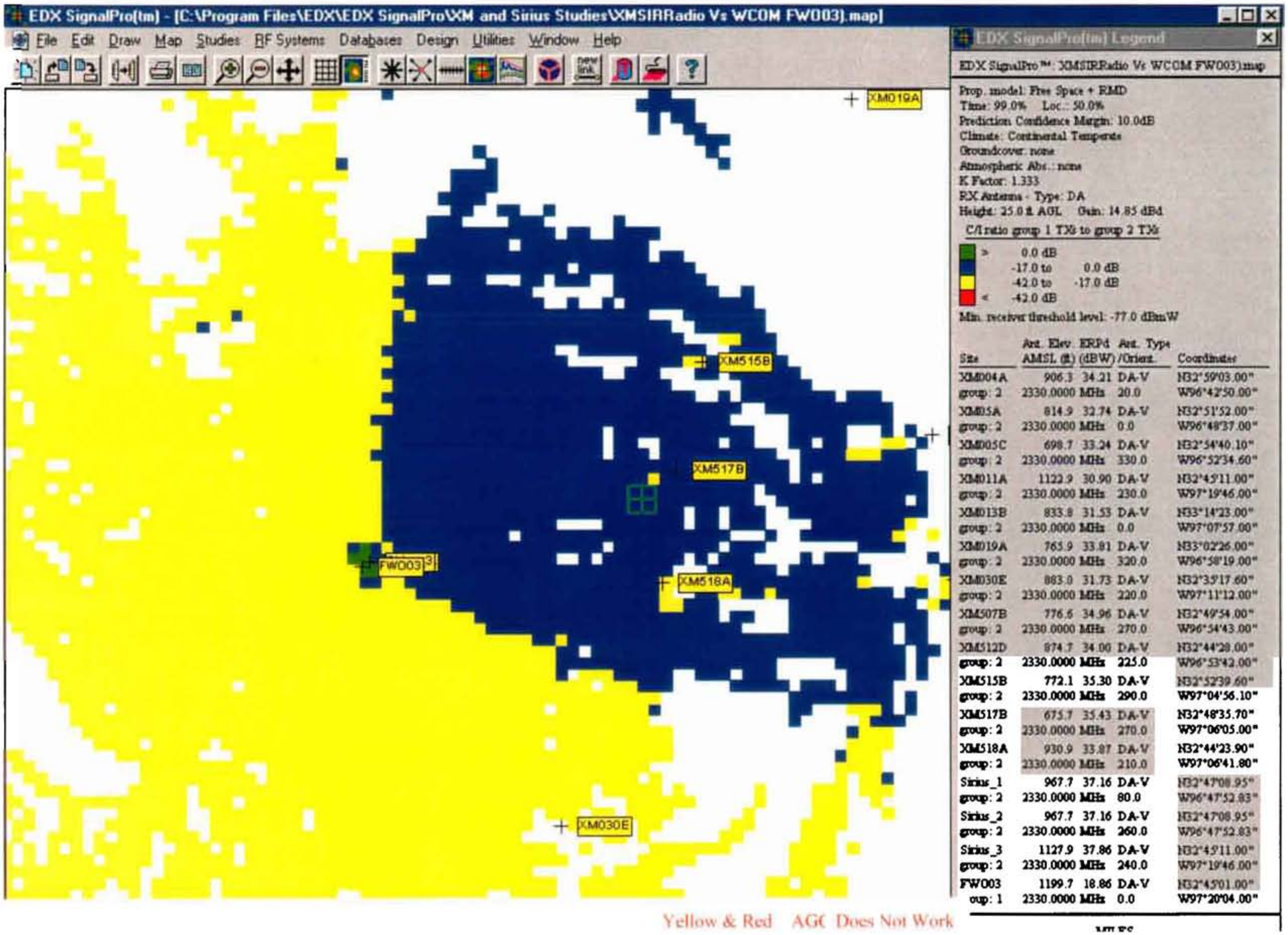
# Figure 20
# SDARS (XM & Sirius) Vs. WorldCom (FW002)



# Figure 21
# SDARS (XM & Sirius) Vs. WorldCom (DAL08)



# Figure 22
# SDARS (XM & Sirius) Vs. WorldCom (FWO03)



# Figure 23
# SDARS (XM & Sirius) Vs. WorldCom (DAL08)
# (Max SDARS EIRP)